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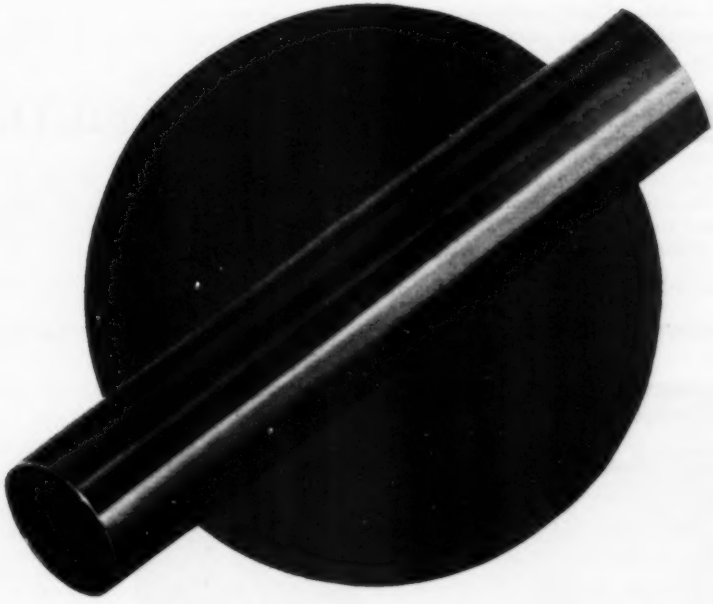

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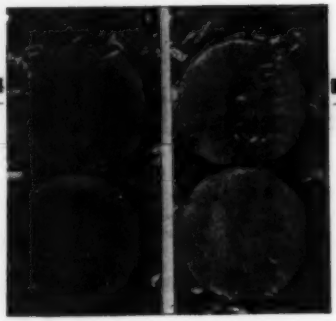

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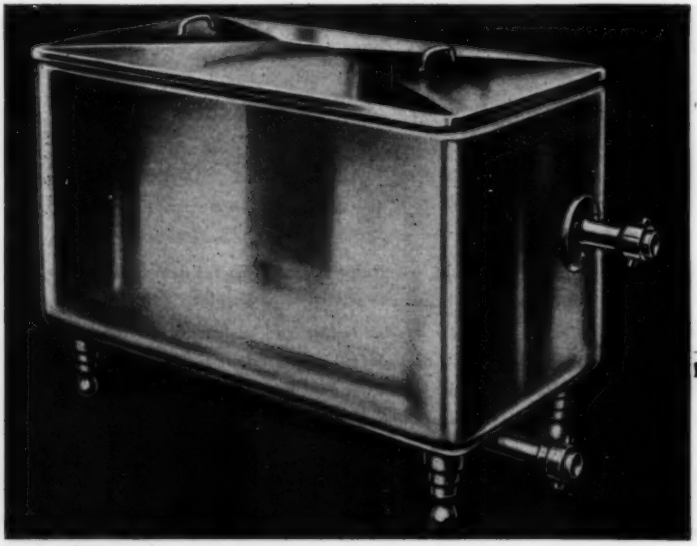

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JOURNAL OF DAIRY SCIENCE

VOLUME XIX MAY, 1936 NUMBER 5

VITAMIN D STUDIES IN CATTLE. III. INFLUENCE OF SOLAR ULTRAVIOLET RADIATION UPON THE BLOOD CHEMISTRY AND MINERAL METABOLISM OF DAIRY CALVES*

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There seems to be fairly general agreement among investigators at the present time that young, growing dairy calves require and utilize vitamin D and/or radiant energy but definite information on the influence of solar ultraviolet radiation upon the blood chemistry and mineral metabolism of these animals is not available. Raczynski (1), however, produced the first evidence of the therapeutic value of radiant energy when he subjected the bodies of two young puppies of the same litter and nursed by their mother, to chemical analysis. One puppy had been kept in the sunlight for six weeks and the other one had been deprived of sunlight for the same period. The body of the first puppy contained much more calcium and phosphorus than did that of the second puppy. He concluded from this experiment that the lack of sunlight was one of the causes of rickets.

Some investigators (2–4) have reported that calves do not require or utilize the radiant energy from the sun since calves which were grown in the dark and fed ordinary rations apparently did just as well as calves which had access to sunshine. In a progress report by Bechdel, Dutcher and Tucker (5), it was indicated that vitamin D therapy was just as applicable to the bovine as to other species of animals. Hill (6) has demonstrated the beneficial influence of direct irradiation of calves with a carbon-arc lamp and the protection against rickets which cod liver oil afforded.

Huffman (7) has shown that calves which had received rations low in vitamin D and kept out of contact with sunshine developed rickets while calves on the same basal ration turned outside to sunshine or had their rations supplemented with cod liver oil did not manifest the symptoms of rickets. Other investigators have confirmed and amplified the above findings (8–11). Rosenkranz (12) has described changes in the thyroids of young cattle. Cattle which were kept in stalls out of contact with sunshine

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exhibited a marked increase in parenchyma with a diminished number of follicles and colloidal content while cattle out on pasture, getting plenty of sunshine, had normal thyroids, well filled follicles and little parenchyma.

The purpose of this investigation was to study the relationship of solar ultraviolet radiation to the prevention and cure of rickets in order to obtain more fundamental information in regard to the role of vitamin D in the nutrition of the dairy calf.

EXPERIMENTAL

Eight healthy grade Holstein calves were used in this experiment, three being males and five females. From birth to about 30 days of age the calves received whole milk twice daily in amounts according to the needs of each calf, after which time the whole milk was replaced by skim milk and a mixture of corn and oats. The mixture of corn and oats was replaced at about 90 days of age by the rachitogenic grain mixture, the composition of which has been previously reported (10–11). The skim milk was discontinued at about 120 days of age.

In addition to this ration, C–97 received 10 cc. of cod liver oil per day and alfalfa hay ad lib. from the 14th to the 74th day of age. C–106 received timothy hay ad lib. from the 183rd to the 263rd day of age.

Calves C–118, C–151 and C–167 were fed the rachitogenic grain mixture and kept out of doors during the day to determine the efficacy of the ultraviolet rays from the sun in the prevention of rickets. C–118 was also exposed to the rays of a carbon-arc lamp for 5 minutes per day from December 10, 1931 to January 19, 1932 and for 10 minutes per day from February 28 to March 29, 1932. Calves C–97, C–106 and C–117 were used to determine the curative value of solar ultraviolet radiation after the onset of rickets. Calves C–111 and C–116 were used to determine the length of time required to deplete the calves of their vitamin D storage after having spent the spring and early summer months out of doors.

The calves which were kept indoors during the day were turned into a bare lot at night for exercise. They were offered water twice daily. Shavings were used for bedding. The calves were weighed every 10 days and measured for height at withers once a month.

Blood samples were obtained every 2 weeks, in many cases every week, from the jugular vein of each of the experimental calves and the plasmas were analyzed for calcium, inorganic phosphorus (13) and magnesium (14) by methods which have been recorded. The values which are given in the tables are the mean concentrations for the respective periods. The 8th rib on the right side, a section of the orbital plate and the right dental pad were used for the determination of ash, calcium, phosphorus and magnesium by methods which have also been recorded (10). The feces and urine, which were collected separately by means of pails and shovels by attendants, were

weighed or measured at the end of each 24-hour period. The excreta and feed samples were composited for each experimental period and aliquot samples of each were taken for chemical analysis. The methods of analysis were the same as in previous work (15).

RESULTS

Antirachitic Value of Solar Ultraviolet Radiation to Calves

In order to determine the protective action of solar ultraviolet rays, three calves were fed the rachitogenic ration and allowed to exercise in a bare lot during the day. The amounts of direct solar radiation which they received varied from day to day depending upon weather conditions.

Calf C–118. This calf was born February 19, 1931, and was turned outside for the first time February 26, 1931. A blood sample taken from this calf at 15 days of age gave normal values. Blood samples were secured at weekly intervals until the calf was changed to the rachitogenic ration at about 90 days of age and at two-week intervals thereafter. Table 1 presents the experimental data secured from this calf and shows a typical example of the protection against rickets afforded by exposure to solar ultraviolet radiation as revealed by the blood plasma data. It is also of interest to note the seasonal variations in the plasma calcium and inorganic phosphorus values. The calcium shows a tendency to drop during January and then increase to a maximum in April. The decline in the inorganic phosphorus and magnesium during January, February and March was more pronounced even though the calf had been exposed to the rays of a carbon-arc lamp during parts of these months. C–118 was removed from this phase of the experiment in May, 1932.

Calf C–151. This calf was bled at 15 days of age and every 2 weeks thereafter. As shown in Table 1, the blood data do not indicate rickets. This calf was normal in every respect when slaughtered at 194 days of age. The results of the analysis of some of the bones appear in Table 5.

Calf C–167. This calf was turned outside in a dry lot daily as soon as good practice would permit. The calf was bled at 2 days of age and every two weeks thereafter. Table 1 presents the monthly composite values for the duration of the experiment. These values do not reveal any indications of a rachitic nature. The calf was normal in every respect when removed from the experiment at 191 days of age. The blood values indicate, however, a seasonal decline due to the decrease in the intensity of the solar ultraviolet rays.

Curative Value of Solar Ultraviolet Radiation After the Onset of Rickets

Calf C–97. This calf was first bled at 140 days of age at which time the plasma calcium and inorganic phosphorus values were normal. The next blood sample was secured when the calf was 190 days of age. By this time

TABLE 1

Data pertaining to calves which received the rachitogenic ration supplemented with solar ultraviolet radiation

CALF	DATE	AGE	WEIGHT	AV. DAILY INTAKE			PLASMA		
				Ca	P	Mg	Ca	P	Mg
no.		*mo.*	*lb.*	*gm.*	*gm.*	*gm.*	*mg. per 100 cc.*		
C–118	3–21–31	1	96	4.7	3.7	0.5	11.0	6.68	1.81
	4–20	2	129	6.3	5.8	0.9	11.2	7.35	1.29
	5–20	3	167	7.6	8.1	1.7	11.5	7.58	1.66
	6–19	4	208	13.3	9.8	3.1	12.1	7.60	2.61
	7–19	5	238	12.9	8.9	3.8	12.5	7.40	1.76
	8–18	6	269	12.8	8.1	4.5	11.2	7.69	2.88
	9–17	7	313	14.7	9.4	5.2	11.9	8.61	2.50
	10–17	8	354	16.4	10.7	5.9	11.9	8.61	2.36
	11–16	9	407	16.5	10.7	5.9	11.7	8.78	2.94
	12–16	10	438	16.6	10.7	6.0	11.8	8.40	2.99
	1–15–32	11	476	17.7	12.3	6.4	11.4	6.61	2.30
	2–14	12	524	20.8	13.1	7.5	11.8	6.60	2.26
	3–15	13	557	21.0	13.7	7.6	13.7	6.72	2.35
	4–14	14	579	20.9	13.9	7.5	13.9	8.05	2.79
	5–14[1]	15	637	21.0	14.1	7.5	13.5	8.78	2.60
C–151	4–3–32	1	105	6.3	5.0	0.6	12.3	6.40	2.33
	5–3	2	123	8.2	6.6	0.9	13.5	6.91	2.09
	6–2	3	163	11.4	8.7	2.0	13.6	7.80	2.22
	7–2	4	214	14.4	10.8	3.1	14.7	7.81	2.76
	8–1	5	252	13.7	8.8	4.7	14.1	7.53	3.47
	8–31	6	257	11.6	6.9	4.2	12.9	7.20	2.39
	9–14[2]	7	288	11.7	6.8	4.2	13.1	7.84	2.52
C–167	5–25–32	1	104	5.6	4.2	0.5	13.1	6.41	2.48
	6–24	2	136	9.1	7.9	1.4	14.7	7.40	2.55
	7–24	3	176	10.4	10.8	2.7	14.8	8.65	2.42
	8–23	4	206	15.1	11.7	3.4	13.6	8.48	1.87
	9–22	5	239	10.3	7.1	3.8	12.4	7.18	1.98
	10–22	6	262	11.0	7.5	4.4	11.8	8.42	2.47
	11–2[3]	7	280	13.3	9.3	5.3	11.3	6.58	1.74

[1] Removed from experiment.

[2] Slaughtered at 194 days of age, no evidence of rickets.

[3] Changed to another experiment at 191 days of age.

the calcium had declined to 6.6 mg. per 100 cc. of plasma but the inorganic phosphorus remained within the normal range. When the calf was turned outside on March 5, the plasma calcium and inorganic phosphorus values were 7.6 and 5.90 mg. The rachitic condition became worse and the calf continued to show signs of stiffness and irritability although it had received some radiant energy. No improvement was noticed in the condition of the calf until it had been outside for about 42 days. By this time the intensity of the ultraviolet radiation had increased sufficiently to cause a reversal in the downward trend of the blood constituents. The rachitic symptoms were completely alleviated by May 15, when the calcium and inorganic phosphorus increased to 11.6 and 8.74 mg., respectively. Table 2 shows the cessation of growth from January to April during which time the calf was suffering from

TABLE 2

Data pertaining to calves whose rachitogenic rations were supplemented with solar ultraviolet radiation after the onset of rickets

CALF	DATE	AGE	WEIGHT	AV. DAILY INTAKE			PLASMA		
				Ca	P	Mg	Ca	P	Mg
no.		mo.	lb.	gm.	gm.	gm.	mg. per 100 cc.		
C–97	8–13–30	1	85	5.9	4.5	0.7			
	9–12	2	115	7.5	5.7	1.1			
	10–12	3	155	9.7	7.7	2.1			
	11–11	4	207	11.7	9.8	3.0			
	12–11	5	241	11.1	7.7	3.9	11.3	7.35	1.09
	1–10–31	6	292	13.0	9.0	5.0	6.6	7.08	
	2–9[1]	7	296	13.2	9.1	5.1	7.0	7.19	
	3–11[2]	8	292	14.0	8.1	4.4	7.4	5.92	1.51
	4–10	9	299	11.0	7.6	4.3	8.8	5.70	2.01
	5–10[3]	10	339	13.3	9.2	5.1	12.1	8.11	1.47
	6–9	11	390	15.3	10.7	5.9	11.8	7.66	1.85
	7–9	12	430	16.4	11.4	6.3	11.1	7.54	2.57
	8–8	13	454	17.5	12.2	6.7	12.4	7.34	3.21
	9–7	14	491	17.5	12.2	6.7	13.5	7.26	3.41
	10–7[4]	15	526	17.5	12.2	6.7	11.5	8.27	2.85
C–106	12–2–30	1	123	6.1	4.8	0.5			
	1–1–31	2	158	6.9	6.7	1.5	5.6	7.23	
	1–31[5]	3	186	7.8	7.2	1.9	6.5	7.02	1.94
	3–2	4	207	12.6	9.4	3.3	5.8	7.46	
	4–1[6]	5	211	8.9	6.2	3.4	6.9	5.34	1.60
	5–1	6	214	9.5	6.6	3.6	7.4	5.29	2.07
	5–31	7	209	9.3	5.9	3.5	7.7	4.66	1.95
	6–30	8	207	8.7	5.5	3.2	7.8	4.14	1.65
	7–28[7]	9	198	12.6	5.7	4.0	8.0	3.44	2.82
	8–29	10	201	8.8	5.8	3.2	11.3	3.75	3.18
	9–28	11	223	11.2	7.5	4.1	11.8	6.54	3.43
	10–28[8]	12	266	13.6	9.3	5.1	11.3	6.52	2.17
	11–27	13	304	14.4	9.9	5.4	10.9	6.30	2.42
	12–27	14	345	16.0	11.0	6.0	11.2	6.57	2.31
	1–26–32[9]	15	392	17.7	12.2	6.7	11.5	6.16	2.14
C–117	12–30–30	1	86	4.5	3.6	0.5			
	1–29–31	2	123	6.3	5.8	1.0			
	2–28[10]	3	145	7.0	7.3	1.4	9.4	6.20	0.99
	3–30[11]	4	179	11.9	9.1	2.8	6.3	6.98	1.26
	4–29	5	208	10.0	6.7	3.4	11.2	7.62	1.85
	5–29	6	257	12.7	8.5	4.6	11.4	8.00	1.87
	6–8[12]	7	272	13.7	9.1	4.9	10.9	7.23	1.64

[1] Stiffness first observed 2–11–31.
[2] Turned outside into sunshine after 3–5–31.
[3] No evidence of rickets 5–19–31.
[4] Changed to another experiment.
[5] Tetanic convulsion 1–26–31.
[6] Legs badly bowed 4–15–31.
[7] Turned outside into sunshine after 7–27–31.
[8] No evidence of rickets 10–2–31.
[9] Changed to another experiment 1–26–32.
[10] Tetanic convulsion when turned outside 2–27–31.
[11] Stiffness and irritability 3–20–31.
[12] No evidence of rickets when slaughtered 6–8–31.

active rickets. The table also shows a tendency toward a seasonal variation in the plasma calcium and inorganic phosphorus. The calf was removed from this phase of the experiment on October 7, 1931. Table 5 presents the ash and percentage composition of some of the bones at the time of slaughter.

C–106. When this calf was first bled at 30 days of age the calcium and inorganic phosphorus values were 5.6 and 7.23 mg. per 100 cc. of plasma.

TABLE 3

Data pertaining to calves whose rachitogenic ration had been supplemented with solar ultraviolet radiation for 5 months and then deprived of this energy

CALF	DATE	AGE	WEIGHT	AV. DAILY INTAKE			PLASMA		
				Ca	P	Mg	Ca	P	Mg
no.		*mo.*	*lb.*	*gm.*	*gm.*	*gm.*	*mg. per 100 cc.*		
C–111	12–12–30	1	113	4.8	3.9	0.6			
	1–11–31	2	113	4.3	3.5	0.5			
	2–10	3	139	5.8	5.1	0.8	8.8	6.50	
	3–12	4	167	10.4	7.8	2.6	7.6	5.19	2.09
	4–11	5	191	8.4	5.5	3.0	7.2	7.40	1.58
	5–11	6	223	10.7	7.0	3.8	11.3	7.48	2.24
	6–10	7	244	11.7	7.7	4.3	11.0	7.94	2.70
	7–10	8	288	13.2	8.7	4.7	11.2	7.25	2.88
	8–9[2]	9	309	13.9	9.1	5.0	11.8	7.41	3.04
	9–8	10	367	14.0	9.1	5.0	11.7	8.58	3.16
	10–8	11	412	15.5	10.1	5.6	10.9	8.42	3.15
	11–7[3]	12	432	15.6	9.2	5.1	10.0	6.92	3.14
	12–7	13	458	15.4	9.1	5.0	9.1	6.72	2.65
	1–6–32[3]	14	460	13.8	9.1	4.9	8.2	5.90	2.17
	2–5	15	460	15.3	10.1	5.5	9.2	4.16	2.13
	2–29[4,5]	16	443	11.2	7.5	4.0	8.2	4.81	2.82
C–116	12–29–30	1	114	5.9	4.3	0.6			
	1–28–31	2	124	6.7	5.8	0.8	8.8	7.23	
	2–27	3	131	7.6	6.6	1.2	9.1	6.79	2.06
	3–29	4	164	11.7	8.7	2.6	9.1	5.70	1.57
	4–28	5	164	6.8	4.4	1.9	8.4	5.57	1.55
	5–28	6	216	11.5	7.3	4.0	10.5	6.66	2.06
	6–27	7	254	15.5	8.9	4.9	11.0	7.55	2.50
	7–27[1]	8	276	14.3	9.1	5.1	12.1	7.47	2.46
	8–26	9	324	14.8	9.1	5.2	11.3	7.02	3.31
	9–25	10	349	14.7	9.1	5.2	10.4	7.55	3.61
	10–25	11	352	14.8	9.1	5.2	9.1	7.62	2.70
	11–24	12	364	14.6	9.1	5.2	8.3	5.48	2.63
	12–24[6]	13	368	14.0	9.1	5.0	7.5	6.07	1.70
	1–23–32	14	375	14.2	9.3	5.1	7.3	5.12	1.84
	2–22	15	364	14.2	9.3	5.1	7.9	3.40	1.99
	3–15[7–9]	16		8.5	5.6		9.4	2.97	2.26

[1] Sunshine discontinued 7–16–31.

[2] Tetanic convulsions 10–24–31.

[3] Stiffness first observed 1–10–32.

[4] Fractured vertebra 2–25–32.

[5] Coma, slaughtered 2–29–32.

[6] Stiffness first observed 12–27–31.

[7] Tetanic convulsion 3–1–32.

[8] Fractured pelvis 3–9–32.

[9] Died 3–15–32.

During the next seven months the calcium values increased slowly to a maximum of 8.6 mg. while the inorganic phosphorus values progressively decreased to a minimum of 1.95 mg. when the calf was turned outside to brilliant sunshine in July. The rachitic condition was severe, the joints had become enlarged and the calf could stand only with difficulty. The change from the deprivation of sunshine to brilliant sunshine caused an immediate and considerable increase in the plasma calcium but failed to cause the inorganic phosphorus to return to normal until the middle of September. The rachitic condition was completely alleviated by October and the calf did not show any indication of rickets when removed from the experiment in January, 1932. Table 2 shows the lack of growth and loss of weight during the time that the rachitic conditions was most severe. The analyses of some of the bones of C–106 are presented in Table 5.

Calf C–117. The calcium and inorganic phosphorus values for this calf at 58 days of age were 9.6 and 6.13 mg. per 100 cc. of plasma. It was turned

TABLE 4

Metabolism data secured from two calves which received the rachitogenic ration supplemented with sunshine and then deprived of sunshine

CALF		AV. DAILY INTAKE	AV. DAILY OUTGO			BALANCE	STORED	PLASMA		
			Urine	Feces	Total			Ca	P	Mg
no.		gm.	gm.	gm.	gm.	gm.	%	mg. per 100 cc.		
C–111[1]	Ca	15.10	1.31	5.50	6.81	8.29	54.9	11.6	8.16	2.50
	P	10.24	2.00	3.00	5.00	5.24	51.2			
7/9/31	Mg	4.18	1.00	4.33	5.33	–1.15				
	N	83.20	43.62	14.43	58.05	25.15	30.2			
C–116[2]	Ca	15.44	0.55	6.86	7.41	8.03	52.0	12.0	7.39	1.81
	P	10.25	1.44	2.71	4.15	6.10	59.5			
7/9/31	Mg	4.22	1.00	3.81	4.81	–0.59				
	N	83.24	43.70	17.16	60.86	22.38	26.9			
			Calves deprived of sunshine							
C–111[3]	Ca	12.60	0.08	13.49	13.57	–0.97		11.6	7.38	4.15
	P	7.46	2.23	9.07	11.30	–3.84				
10/21/31	Mg	4.51	0.54	4.08	4.62	–0.10				
	N	87.55	28.96	22.46	51.42	36.12	41.3			
C–116[3]	Ca	13.09	0.24	10.92	11.16	1.93	14.7	8.9	4.78	3.83
	P	7.45	4.63	4.34	8.97	–1.52				
10/28/31	Mg	4.51	1.20	3.78	4.98	–0.47				
	N	87.55	61.99	12.45	74.44	13.11	15.0			

[1] Developed rickets during Jan. 1931, turned outside Feb. 1, 1931, no evidence of rickets and blood picture normal by May 1, 1931.

[2] Developed rickets during Jan. 1931, turned outside Feb. 1, 1931, no evidence of rickets and blood picture normal by June 1, 1931.

[3] Sunshine discontinued July 17, 1931.

outside February 27, 1931 to receive advantage of the winter sunshine. The limited amount of sunshine which it received during February and March was insufficient to maintain the plasma calcium within the normal range but it did maintain the inorganic phosphorus. C–117 had a tetanic convulsion at 90 days of age and manifested mild rickets at 100 days of age. The calf was slaughtered at 190 days of age but no evidence of rickets was observed at that time. The age, weight, the average daily mineral intake and the blood picture are presented in Table 2. The bone data are shown in Table 5.

TABLE 5

Ash and mineral content of bones from the experimental calves

CALF	BONE	AGE	WEIGHT	ASH	Ca	P	Mg	TERMINAL PLASMA		
								Ca	P	Mg
no.		*days*	*lb.*	%	%	%	%	*mg. per 100 cc.*		
C–97	8th	844	645	59.25	23.49	10.06	1.20	9.2	7.06	1.79
C–106	right	1002	662	57.35	22.60	9.91	0.51	10.1	4.46	2.60
C–111	rib	474	425	49.02	19.66	8.80	0.75	8.0	4.00	3.45
C–116		472	317	44.15	17.38	7.66	0.53	8.1	3.51	2.33
C–117		190	272	53.80	19.60	10.15	0.43	10.9	7.23	1.64
C–151		194	288	50.80	19.29	9.01	0.73	13.8	7.44	2.58
C–97	Orbital			54.05	20.19	10.17	1.43			
C–106	plate			59.55	23.22	9.86	1.20			
C–111				50.97						
C–116				50.00						
C–117				53.57						
C–151				51.75	20.18	9.51	1.18			
C–97	Dental			59.85	23.75	10.67	0.85			
C–111	pad			47.29						
C–116				44.15						
C–117				56.68						
C–151				57.30	22.21	10.62	0.64			

Duration of the Reserve of Vitamin D in the Calf's Body After Being Deprived of Solar Ultraviolet Radiation

Calf C–111. This calf was first turned outside to winter sunshine at 80 days of age. The calcium and inorganic phosphorus values were 8.5 and 6.51 mg. per 100 cc. of plasma at this time. The intensity of the solar ultraviolet rays during February and March was insufficient to maintain the calcium and inorganic phosphorus within normal limits. Evidences of rickets or irritability were not observed in this calf. The plasma calcium and inorganic phosphorus returned to normal during April and remained within the normal range until after the metabolism trial in July.

In order to secure a better idea of how efficiently this calf was utilizing

its feed after constant exposure to spring and summer sunshine, a 7-day metabolism trial was run. The results, tabulated in Table 4, show that the calf was storing 54.9 per cent of the calcium and 51.3 per cent of the phosphorus contained in the feed.

After the completion of the metabolism trial, the calf was continued on the same ration but was deprived of sunshine. The results, presented in Table 3, show that the deprivation of solar radiation caused the plasma calcium values to decline steadily but the inorganic phosphorus increased temporarily before it progressively declined to the termination of the experiment.

On October 21st, 106 days after C–111 had been deprived of sunshine, the second 7-day metabolism trial was started. The results, recorded in Table 4, now show that the calf was losing calcium and phosphorus from its body. The plasma calcium and inorganic phosphorus values during this period (11.6 and 7.38 mg.) do not indicate the severe drain which was taking place but by the following week these values had dropped to 9.4 and 6.41 mg., respectively. The effect of the rachitogenic ration upon the blood picture of C–111 did not begin to appear until the week following the metabolism trial when the plasma calcium began to fluctuate widely and the inorganic phosphorus steadily declined. C–111 became extremely rachitic by February, 1932. On February 25 a vertebra became fractured and the animal was slaughtered. The ash values are presented in Table 5.

Calf C–116. This calf was first bled at 60 days of age when it was turned outside to winter sunshine. The calcium and inorganic phosphorus values were 8.8 and 7.23 mg. per 100 cc. of plasma. The blood picture of this calf was similar to that of C–111 because the intensity of the solar ultraviolet rays was insufficient to keep the concentrations of plasma calcium and inorganic phosphorus up to normal. These elements did not regain their normal values until late in May but evidences of rickets were not observed. By the time of the metabolism trial in July the concentrations of plasma calcium and inorganic phosphorus were 12.0 and 7.39 mg. The metabolism trial lasted for 7 days as in the case of C–111. The results of the trial show that C–116 was storing 52.0 per cent of the calcium in the feed and 59.5 per cent of the phosphorus as a result of the therapeutic effects of the radiant energy.

After the completion of this trial C–116 was deprived of the benefit of sunshine. An examination of Table 3 shows that there was a progressive and considerable decrease in the concentration of plasma calcium, a temporary increase in the concentration of inorganic phosphorus and then a precipitous drop in the phosphorus which continued to the fatal termination of the experiment.

On October 28th, 113 days after C–116 had been deprived of sunshine, a second 9-day metabolism trial was started. The results of this trial show

that the calf was storing a small percentage of the calcium in the feed but that the phosphorus balance was negative. The concentrations of plasma calcium and inorganic phosphorus at this time would also indicate this condition. The effect of the rachitogenic ration upon the blood picture of C–116 was observable for 6 weeks previous to the trial. The plasma calcium fluctuated widely but significant changes in the inorganic phosphorus did not occur until the week of the trial when the phosphorus abruptly dropped from 7.76 to 4.38 mg.

C–116 became extremely rachitic following the metabolism trial and was slaughtered in March, 1932, after the pelvis had become fractured. The data secured from the metabolism trial are presented in Table 4 and the bone data in Table 5.

DISCUSSION

The basal rachitic ration plus daily exposures to solar ultraviolet radiation produced normal growth and development in calf C–118 from birth to 15 months of age and from birth to 7 months of age in calves C–151 and C–167. An examination of the plasma calcium values of these calves reveals the tendency of a seasonal increase in calcium during the early summer months (May, June and July, depending upon the amount and intensity of solar ultraviolet rays) and the corresponding decline during the early winter months (November, December and January). The inorganic phosphorus values show a stronger tendency to increase to a maximum during July and August and then decrease to a minimum during January and February. Neither the physical condition nor the blood values indicated any evidence of rickets in these calves.

The three calves which received the rachitogenic ration (C–97, C–106 and C–117) and were deprived of solar radiation, manifested all of the outward symptoms of rickets within 30 to 90 days after receiving the rachitogenic ration. C–97 did not manifest rickets as soon as C–106 and C–117 because this calf had received 10 cc. of cod liver oil per day and alfalfa hay ad lib. from the 14th to the 74th day of age. The vitamin D reserve was soon depleted, however, after the change to the rachitogenic ration. Anorexia became pronounced, growth ceased and stiffness was evident. Calf C–106 had a convlusion at 85 days of age but the first evidence of rickets, as indicated by stiffness, was at 163 days of age. Timothy hay was offered to the calf at 173 days of age but due to anorexia, she consumed less than 1 pound of hay per day for the next 90 days. This amount of hay was insufficient to afford protection against rickets. C–117 was rachitic when turned outside to March sunshine at 100 days of age.

C–97 and C–117 were completely cured of rickets within 45 days after being exposed to April and May sunshine. It required about 60 days exposure to August and September sunshine to alleviate the rachitic condition

in C–106. The plasma calcium and inorganic phosphorus values of the calves increased to normal within 30 days after the calves were turned outside, with the exception of the inorganic phosphorus of C–106 which required about 60 days.

The concentration of plasma calcium was below normal in both C–111 and C–116 when they were first turned outside in January. The intensity of the ultraviolet rays in the February and March sunshine was insufficient to raise the calcium concentration to normal. The metabolism trials in July demonstrate the antirachitic potency of early summer sunshine. The metabolism data in Table 4 show how efficiently these calves were utilizing the calcium, phosphorus and nitrogen in the ration when they had access to sunshine. The metabolism data of these same calves after being deprived of sunshine for approximately 3 months present a different picture. In both cases there was a reduced or negative balance of calcium and phosphorus due to the defective utilization of these elements and also to a demineralization of the bones. These data also show a shift of calcium from the urine to the feces. There was a marked decrease in the actual amount of calcium excreted through the urine while there was an increase in the actual amount of phosphorus excreted through both the urine and feces. These data indicate that one important defect in rickets lies in the inadequate retention and utilization of calcium and phosphorus.

Under the conditions of this experiment the Ca : P ratio was the same for each calf after being placed on the rachitogenic ration, therefore the limiting factor was the presence or absence of radiant energy. The Ca : P ratio was Ca : P :: 1 : 1.5. The ratio of the retention and total excretion of calcium and phosphorus of C–111 and C–116 during the first trial approached the ratio of these elements in the ration. During the second trial the ratio of the total excretion was Ca : P :: 1 : 1.22 which indicates that the rate of excretion of phosphorus is greater than calcium during the period of active rickets.

The severity of the rachitic condition of C–111 was not as pronounced as in C–116, probably due to the establishment of a larger reserve of calcium, phosphorus and vitamin D. This condition was temporarily associated with the normal concentration of inorganic phosphorus in the plasma although the concentration of calcium and the rate of growth had decreased. In this case the occasional analysis of the blood would not have given reliable information as to the progress of the rachitic condition but when the blood was analyzed every week the progress of the rachitic condition could be followed with some degree of reliability. The nitrogen metabolism apparently had not been disturbed in C–111, whereas C–116 was undergoing a severe metabolic change. This condition is indicated when the rates of growth of C–111 and C–116 between the two trials are compared. C–111 gained 133 pounds while C–116 gained only 72 pounds.

A characteristic symptom of rickets is the disturbance of the calcium

and phosphorus metabolism which results in imperfect calcification of the growing bones. In extreme rickets some of the calf bones become soft, the joints enlarged, the calf becomes stiff and abnormal locomotion results. The results from the bone data indicate a significant difference between the rachitic and non-rachitic bones. Total ash content and the percentages of calcium, phosphorus and magnesium have been included for the 8th right rib, a section of the orbital plate and the right dental pad. The long bones were also subjected to analysis but the results are not included. The insignificant differences in the ash content of the long bones indicate that changes in the mineral content of these bones tend to take place very slowly even when the calf is suffering from active rickets. After comparing the normal values with the results obtained from the analyses of these bones and other bones in more severely rachitic calves, it was decided to omit future analyses of all except the rib bones. By analyzing definite lengths or zones of the rib, the shift in calcium and phosphorus from the bone to the blood can be followed to better advantage. This method of studying some of the chemical components of rachitic and normal ribs will be reported in a subsequent paper.

It was not the purpose of this report to postulate on the mechanism of vitamin D action but to show the essentiality of radiant energy in the dietary régime of the dairy calf. One observation seems pertinent, however, all of the rachitic calves had a large accumulation of bile in the gall bladder at autopsy. The color and viscosity were also abnormal. Variations in color from brick-red to yellow were noted, while the viscosity was analogous to firm egg-white. This pathological observation may have some significance when viewed in the light of recent reports by Greaves and Schmidt (16) (17) who demonstrated the rôle of bile in the transport of vitamin D across the intestinal wall.

SUMMARY

1. Young calves are susceptible to rickets when solar ultraviolet radiation or some form of vitamin D is lacking in their dietary régime.

2. When the concentrations of calcium and inorganic phosphorus in the plasma are determined at weekly intervals, the progressive downward trend of either or both of these constituents usually preceded all other outward evidence.

3. The deficiency of radiant energy was also manifested by anorexia, by cessation of or decrease in the rate of growth, stiffness and bowing of the forelegs and finally, by the reduction of the ash and mineral content of the moisture-free, fat-free rib.

4. The exposure of rachitic calves to early spring sunshine caused the concentrations of calcium and inorganic phosphorus in the plasma to increase markedly. There was also a significant increase of these constituents in normal calves during the summer months and a corresponding decrease during the winter months.

5. These experiments demonstrate the effectiveness of solar ultraviolet radiation in enabling or permitting the calf to utilize more economically the materials present in the ration but not available to the body without the benefit of radiant energy or a supplementary form of vitamin D.

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EFFECTS OF TIME AND TEMPERATURE OF HOLDING MILK HEAT-TREATED AT VARIOUS TEMPERATURES UPON ITS SUBSEQUENT COAGULATION BY RENNET*

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The author (1) has shown that artificial "milks" composed of a calcium caseinate-colloidal calcium phosphate sol exhibit a hysteresis-like effect when heat-treated and coagulated with rennet at various intervals after heating. This effect which results in a progressive loss of coagulability as the interval between heating and addition of rennet increases, has been shown by Mattick and Hallett (2) and Moir (3) to occur in natural milk. In order to obtain further data on this phenomenon in natural milk observations were made on the effects of the time and temperature of holding on the rennet coagulability of heat-treated skimmilks.

STUDIES WITH MILK PASTEURIZED BY THE HOLDING METHOD

During the entire study both the holding method and the flash pasteurization process were used. With the first method two liters of fresh skimmilk were placed in a loosely stoppered flask and rapidly heated in a water bath to 65° C., 75° C. or 85° C. and maintained at the respective temperature for 30 minutes. A portion of each lot of milk was then kept at the heating temperature while two other portions were removed and rapidly cooled, one to 35° C. and the other to 5° C., each being held at that temperature. Two 50 ml. samples were immediately removed from that portion cooled to 35° C. and rennet added for coagulation. Duplicate 50 ml. samples from each of the above portions were removed and rennet added at various intervals after the initial heating period. All samples were coagulated at 35° C. in the electrically heated and controlled water bath previously (1) described. At least two complete determinations were made for each temperature that was studied.

Each sample was placed in a coagulation tube 10 minutes before addition of the rennet in order to adjust itself to the temperature of the bath. One ml. of a 3 per cent rennet solution was added to each 50 ml. of milk, a stopwatch started and the milk stirred for 30 seconds. After an appropriate interval the screw clamp closing the bottom of the coagulation tube was re-

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leased slightly and a fine stream of milk allowed to run into a beaker. When coagulation was observed on the sides of the glass the watch was stopped and the coagulation time recorded.

In each series of experiments unheated control samples were coagulated with rennet at the beginning and again at the completion of the experiment. During the 3 hour interval the raw milk was held at 20° C. In all cases the coagulation time of these control samples was easily within experimental error.

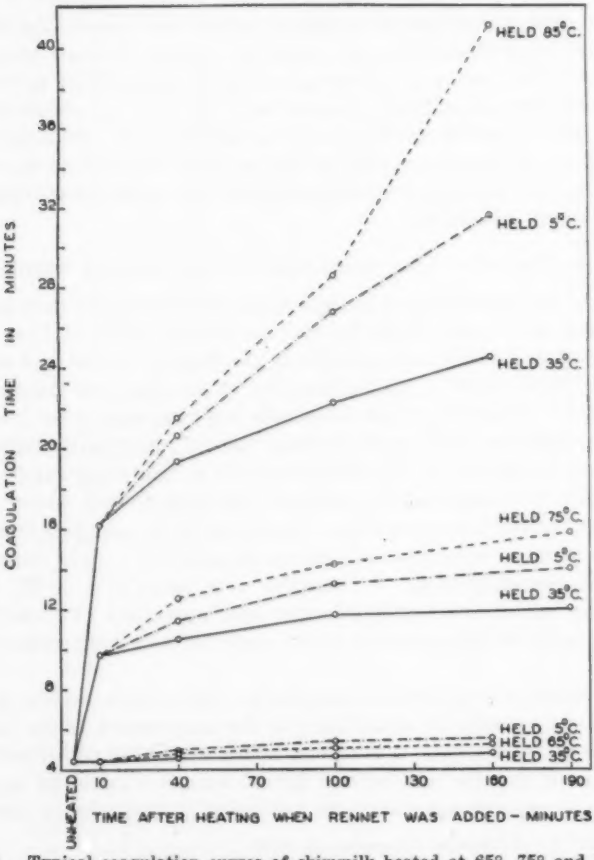

FIG. 1. Typical coagulation curves of skimmilk heated at 65°, 75° and 85° C. for 30 minutes and coagulated with rennet at 35° C. after aging for various intervals at 5°, 35° C. and at the heating temperature. Lower group of curves represents milk heated at 65° C., the middle group 75° C. and the upper group 85° C.

The typical coagulation curves of the milks heat-treated by the holding method are presented in Fig. 1. This graph shows the relation of the time

of coagulation to the interval after the initial heating period when rennet was added. There are three distinct groups of curves; the lower group represents milks which were initially heat-treated at 65° C., the middle group those milks heated at 75° C. and the upper group those milks heat-treated at 85° C.

If one compares the immediate effect of heating on the coagulability it is readily seen that the coagulation time increases with the temperature of heat-treatment, a fact which has been known for many years. However, when milk is heated at 65° C. for 30 minutes and rennet added immediately at a lower temperature (35° C.) there is an actual acceleration in the rate of coagulation. The scale of the graph is too small to show the slight acceleration which usually occurs. It is more pronounced in some milks than in others. This increased coagulability as a result of low temperature heating was first observed by Stassano and Talarico (4) and later confirmed by Rupp (5) and Mattick and Hallett (2). When the temperature of heat-treatment is increased from 65° C. to 75° C. the effect is to decrease the initial coagulability slightly more than one-half, while heating at 85° C. caused a greater retardation, the milk requiring 4 times as long to coagulate as the unheated control.

The coagulation time of the heat-treated milks does not remain constant but gradually increases as these milks are aged before the addition of rennet. Aging of the milks initially heated at 65° C. only slightly retards their coagulability, whereas the retardation becomes more pronounced as the initial heating temperature increases. Furthermore, the temperature at which the heat-treated milks are held also influences their rate of coagulation. Regardless of the initial heating temperature, in all cases those portions held at 35° C. coagulate more rapidly than those held either at 5° C. or at the initial heating temperature.

Aging the heat-treated milks at 5° C. retards coagulation less than holding at the heating temperatures of 75° C. or 85° C. Again, those milks heated initially at 65° C. show the least effects of aging at different temperatures, the differences becoming more pronounced as the initial heating temperature is raised.

The change in pH as the result of heat-treatment is negligible, rarely exceeding 0.01 pH even at the highest temperature used. The slight change which does occur is always towards a lower value which should tend to cause a more rapid coagulation if there be any effect.

STUDIES WITH FLASH PASTEURIZED MILK

In this part of the study the procedure of aging the various portions of milk heat-treated by flash pasteurization was identical with that already described. A convenient laboratory flash pasteurizer was constructed with three different sizes of tinned-copper sanitary piping 1, 1.5 and 2 inches in

diameter; it is similar to the one described by Moir (3). A diagrammatic sketch of the pasteurizer is shown in Fig. 2. The one inch pipe is two feet

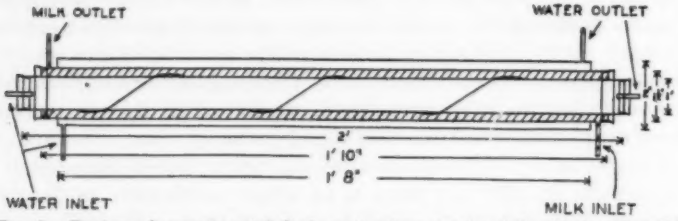

FIG. 2. Design of experimental flash pasteurizer constructed with 1, 1.5 and 2 inch diameter tinned-copper sanitary piping. Shaded portion is the milk chamber.

long and the 1.5 inch pipe is 2 inches shorter while the largest one is 2 inches shorter than the intermediate one. The pipes were telescoped, the two largest ones being uniformly spaced and soldered together while the smallest pipe was fitted into the intermediate one with rubber stoppers. This arrangement permitted easy cleaning of the surfaces which came in contact with the milk. A No. 10 gauge wire was soldered in a spiral around the one inch pipe in order to produce greater agitation of the milk during heating. Appropriate inlets and outlets were soldered into the intermediate and outer pipes, the center pipe being closed on each end with rubber stoppers through which short pieces of glass tubing were inserted.

During the actual operation the unit was placed vertically and the milk permitted to flow by gravity through the intermediate passage. Hot water 10 to 15° C. higher than the final temperature of the milk was pumped through the center and outer passages. The flow of milk was regulated so as to require from 30 to 45 seconds exposure to reach a temperature of 75° C. or 85° C. Approximately 5 minutes were required to collect the two liters of heated milk necessary for each experiment.

The portion of the heated milk held at the pasteurizing temperature was run directly into a flask and immediately immersed in a water bath of the same temperature. The remainder of the milk was allowed to flow from the pasteurizer directly through a Liebeg condenser cooled with tap water and emerged at approximately 35° C. One-half of the cooled milk was placed in a flask and the temperature adjusted exactly to 35° C.; it was held at that temperature in a water bath. The other portion of the milk was promptly cooled to 5° C. by immersing the flask in ice-water.

Immediately after the first portion of milk had been adjusted to 35° C. two 50 ml. samples were withdrawn and rennet added for coagulation. Duplicate 50 ml. samples from each of the above portions of milk were adjusted to 35° C. at various intervals after heating and rennet added. One ml. of a 3 per cent rennet solution was added to each 50 ml. for coagulation, the procedure being identical with that previously described.

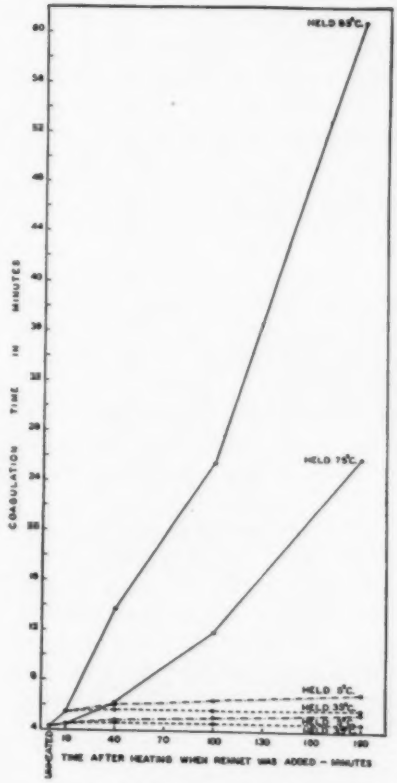

FIG. 3. Typical coagulation curves of skimmilk flash pasteurized at 75° and 85° C. and coagulated with rennet at 35° C. after aging for various intervals at 5°, 35° C. and at the heating temperature. Open circles represent milks heated at 75° C., solid circles heated at 85° C.

The typical coagulation curves in Fig. 3 are of milk heat-treated by flash pasteurization at 75° C. and 85° C. and show the relation of the coagulation time to the interval after heating when rennet was added. The initial effect of the temperature of heating, as shown in these curves, is a retardation of the coagulability; this effect increases with the heating temperature but is not so pronounced as in the milks heated by the holding method. In fact, only a very slight decrease in coagulability is registered by flash pasteurizing milk at 75° C. Likewise the effects of aging flash pasteurized milks at 5° C. and 35° C. are less pronounced than when the holding method of pasteurization is used.

When different aging temperatures are employed the least effects on coagulability are again registered by those portions held at 35° C. followed closely by those samples held at 5° C. Naturally, prolonged holding at the heating temperatures of 75° C. or 85° C. greatly retards coagulation, the highest temperature producing the most pronounced effect.

DISCUSSION

These experimental results indicate that there may be several factors involved in the hysteresis-like phenomenon previously (1) referred to. The time and temperature of aging as well as the temperature of heat-treatment play major rôles. Certainly the initial heating temperatures are of prime importance in influencing the rate of coagulation, especially when the milk is heat-treated by the holding method. These temperatures in turn affect the later behavior during aging, particularly in those milks heated at the higher temperatures.

The effect of the duration of heating is clearly indicated in the flash pasteurization study. Only slight decreases in the rate of coagulation were produced in those heated portions which were promptly cooled after heating while progressively larger losses occurred as portions were aged at the heating temperatures. The same effects were produced in the milks heated by the holding method but were less pronounced. When the two methods of heating are compared it is readily seen too that the short-time heating produces far less retardation in the heated portions than the holding method does.

It is remarkable that all of the heated samples that were aged at 35° C. coagulated more rapidly than those held at 5° C. One would suspect that the higher holding temperature would result in greater losses of coagulability, yet the reverse was true in all cases studied. An adequate explanation of this behavior has not yet been found. Apparently it is not due to an inadequate warming of the cold samples as several trials were made in which those samples were first warmed to 40° C. and promptly cooled to 35° C. before addition of the rennet; no significant differences occurred.

CONCLUSIONS

1. Heat-treating milk at 65° C. for 30 minutes and cooling to 35° C. does not retard its coagulability if rennet is added immediately after heating; in fact, slight increases generally occur.

2. Aging of milk heat-treated at 65° C. for 30 minutes at either 5°, 35° or 65° C. for 3 hours only slightly retards its coagulability.

3. Heat-treating milk at 75° or 85° C. for 30 minutes definitely retards its coagulability with rennet at 35° C.; the loss increases as the heating temperature rises.

4. When milks heat-treated at 75° or 85° C. for 30 minutes are aged at 5°, 35° or at the heating temperature a progressive loss of coagulability results as rennet addition is delayed. The retardation is most pronounced in the milks heated at 85° C.

5. Aging heat-treated milks at 35° C. retards coagulability less than aging at 5° C. or at the heating temperature; the greatest loss occurs when the milks are held at the heating temperature, except those at 65° C.

6. Flash pasteurization of milk at 75° C. only slightly retards its coagulation with rennet at 35° C.; no change in the rate occurs after aging 3 hours at 35° C. and only a slight loss results at 5° C. Holding this milk at the heating temperature naturally causes sharp increases in coagulation time.

7. Flash pasteurization of milk at 85° C. decreases the rate of coagulation but the retardation is not as great as milk heated at 75° C. by the holding method. Aging this milk at 5° or 35° C. causes further small losses in coagulability while holding at 85° C. results in a drastic retardation.

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EFFECT OF TANKAGE ON THE FLAVOR OF MILK

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Tankage is not ordinarily fed to dairy cows but during the 1934–35 feeding season many dairymen fed it as a protein supplement because of its relatively low price. We became interested in and organized a trial to determine the effect of tankage on the flavor of milk.

We experienced difficulty in getting the cows to eat tankage. Some cows refused their grain when as little as a tablespoonful of tankage was mixed with eight to ten pounds of the concentrate mixture. We selected four cows from 32 which would eat the tankage in large quantities when mixed with the concentrate part of the ration. In the group of four cows was one Jersey, one Ayrshire, one Holstein and one cross-bred cow. All had sound udders free from garget. The cows were in approximately the same stage of lactation.

The cows were on the regular herd ration consisting of four parts of oats, four parts of barley, three parts of bran, and two parts of oil meal. Corn silage and a fair grade of alfalfa hay were fed as roughage. The grain ration was fed according to milk production.

The four cows produced an average of 14.07, 29.72, 31.40 and 13.62 pounds of milk respectively per day during the test period. The four cows showed no daily variation of any significance during the seven periods. The cows were receiving 5, 7, 8 and 5 pounds of the grain mixture daily.

When the tankage feeding was begun 25 per cent by weight of the grain ration was replaced by an equal amount by weight of tankage. This level of tankage feeding was continued for four consecutive days, when the tankage was increased to 33⅓ per cent of the grain ration and continued for a second four-day period. Tankage was then increased to fifty per cent of the concentrate ration and continued for the third four-day period.

The concentrate ration and roughage were fed after milking according to the regular barn procedure. Following the 50 per cent tankage-feeding-period fed after milkings, the concentrate part of the ration containing 50 per cent tankage was fed one hour before milking for four consecutive days, and then the time of feeding was changed to two hours before milking, and the feeding continued for another period of four days.

Armour's Feeding tankage was used. The supply of tankage was secured from the supply purchased by the Animal Husbandry Department for hog feeding.

One-half pint sample of milk was taken from each cow at the P.M. milking. The sample was poured directly from the milk pail without cooling or

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aerating. The sample bottles were capped and placed in cold water until 8 A.M. when they were delivered to the Creamery, where they were stored in the refrigerator at a temperature of 40° F. The samples were scored in the afternoon of each day approximately at the same time. The samples were therefore approximately 24 hours old when scored.

The samples were taken out of the refrigerator and heated to about 95° F. and then scored by five judges. Only one of the judges knew the plan of feeding, and the individual cows from which the samples were taken. Each judge scored the milk for flavor only, indicating the score of the milk as excellent, good, fair and poor. Grades in between were indicated by plus or minus. In order to facilitate the compilation of the data, numerical values ranging from 14 to 25 have been placed on the twelve scores.

RESULTS

Table 1 shows the average scores of the milk from the four cows. The average score as given for each judge represents 16 observations, and the average of all judges 80 independent observations.

TABLE 1

*Average score of the milk of four cows for seven consecutive experimental periods as given by the individual judges, together with the average score by all the judges**

INITIAL OF JUDGES	O	T	W	C	K	AV.
Herd ration fed after milking	20.85	20.90	20.60	20.35	21.35	20.81
25 per cent tankage " "	21.00	21.75	20.50	20.50	21.50	21.05
33⅓ " " " " "	20.93	20.37	21.50	20.25	21.00	20.81
50 " " " " "	21.20	21.73	21.60	20.09	21.20	21.16
50 " " " one hr. before	20.87	21.00	21.12		20.87	20.96
50 " " " two hrs. "	21.00	20.31	20.56		20.56	20.60
Herd ration after 4 day interval	20.87	20.87	20.68	20.21	21.20	20.76

* Each score by individual judges represents the average of 16 independent observations, and the average score by all the judges represents the average of eighty observations.

A study of the data indicate very close agreement by the several judges. The greatest fluctuations for the seven periods is from a numerical score of 20.09 to 21.75.

The greatest variation in any one period was from 20.09 to 21.73, which occurred during the 50 per cent tankage feeding period. However the one judge who placed the low score on this series of samples was scoring consistently lower than the other four judges.

The average score of all judges for all periods did not show any appreciable difference. The score of 20.81 previous to the tankage feeding trials, checks very closely with the subsequent tankage feeding periods. The highest average score as well as the highest score of two judges occurred during the 50 per cent tankage feeding period.

The data in Table 2 indicate that the samples of milk from the four cows varied more due to individuality than to the rations fed.

TABLE 2

*Average score of the milk from each of the four cows for the seven consecutive 4-day experimental periods**

COW NO.	106	3–B	383	227
Herd ration fed after milking	18.92	21.28	20.84	21.84
25 per cent tankage " "	20.47	20.95	20.84	21.68
33⅓ " " " " "	20.38	20.94	21.00	21.00
50 " " " " "	20.67	22.00	21.47	21.00
50 " " " one hr. before milking	20.75	21.56	19.93	21.37
50 " " " two hrs. " "	20.62	21.43	19.68	20.43
Herd ration after 4-day interval	21.21	21.84	19.43	20.25

* The score for each cow for each period represents the average of twenty independent observations.

The samples from cows 227 and 3–B were not criticized for off flavor, except on two or three occasions. Samples from cow 106 were criticized very often for having a salty taste. The samples from cow 383 were criticized as watery, sweet, bitter.

It is well known that milk from individual cows varies greatly in flavor, when no specific cause can be given. The samples of milk from cow 227 showed a higher average score than the milk from any other cow. The milk from 3–B, showed the widest variation.

Our findings so far as the effect of tankage on flavor of milk is concerned are essentially the same as reported in Massachusetts Agric. Exp. Station bulletin 321 in which the author concludes: "that the tankage did not effect flavor of the milk in any way."

CONCLUSIONS

1. The feeding of tankage in the grain ration in amounts as high as 50 per cent by weight appears to have no effect on the flavor of milk.

2. The flavor of milk was not affected by the time of tankage feeding even when the tankage was fed one and two hours prior to milking.

3. There were greater variations in the scores of milk samples from individual cows than occurred as a result of tankage feeding during the different periods.

CORN GLUTEN FEEDING AND THE TITRATABLE ACIDITY OF MILK

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INTRODUCTION

The acidity test of milk has been used for some time as a basis for accepting or rejecting milk upon its arrival at milk plants. It provides a quick method at the time of delivery to the plant and its use has been continued although several investigators have shown that misleading information may be secured if the quality of milk is judged solely on the titratable acidity. The usual practice is to reject milk with an acidity above 0.175 per cent.

A representative of one company observed certain farmers producing milk of high acidity who were feeding large amounts of corn gluten feed, one to the extent of 75 per cent of the grain ration. Sulphuric acid is used in the process by which gluten feed is produced. At the suggestion of the company's field representative the corn gluten feed was reduced in this herd, after which the milk passed the weigh stand acidity test.

This matter was referred to the writers, who have since undertaken to determine whether or not large amounts of corn gluten feed in the ration affect the titratable acidity of milk.

Turner and Beach (6) in 1904 found that ensilage in the ration did not increase the titratable acidity of milk.

Duncombe (1) fed lactic acid, acetic acid, butyric acid and phosphoric acid to cows but failed to alter the acidity of milk.

Sommer and Hart (4) have tested the effect on the acidity of milk of feeding concentrated sulphuric acid. They fed up to 120 c.c. of sulphuric acid per day for six days and the acidity of the milk remained unaltered.

Recently, Sommer (5) has ably reviewed the literature and discussed the factors that influence the acidity of milk and milk products and concludes: "Feeding experiments in an attempt to alter the gross chemical composition of milk (fat, casein, total solids content) have in general led to the conclusion that it is impossible to alter the composition of milk in any definite manner. Experimental evidence indicates that a similar conclusion must be drawn with respect to acidity."

FIRST TRIAL

To ascertain the effect of corn gluten feed on the acidity of freshly drawn milk, a ration was made consisting of:

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* The first trial of this series of two was conducted by H. Wilmot Carter and reported in 1934 as a thesis in partial fulfillment of the requirements for the Master's degree.

70 per cent corn gluten feed
10 per cent wheat bran
10 per cent crimped oats
5 per cent linseed oil meal (O. P.)
5 per cent corn hominy

This will hereafter be referred to as the "gluten ration."

The control ration consisted of:

20 per cent wheat bran
20 per cent crimped oats
40 per cent linseed oil meal (O. P.)
20 per cent corn hominy

This will hereafter be called the "no-gluten ration."

Each mixture contained approximately 20 per cent total crude protein. Ten pounds of sodium chloride was added to each one thousand pounds of grain mixture.

The regular herd ration was fed to a third group. This ration, which contained about 20 per cent corn gluten feed, will hereafter be called the "herd ration."

Each animal was fed the same roughage: Two feedings of alfalfa hay, one feeding of native mixed hay, and three light feedings of corn silage per day. The animals were milked three times a day. The milk was titrated with N/10 NaOH immediately after each milking.

Three Ayrshires, two Guernseys and six Holsteins were selected for study. All animals had freshened normally within ten weeks of the beginning of the experiment and were mastitis-free as determined in routine tests by the methods of Plastridge, *et al.* (2, 3). The cows were divided into three groups. Groups I and II each consisted of one Ayrshire, one Guernsey and one Holstein. Group III (control) consisted of one Ayrshire and two Holsteins. One of the remaining two Holsteins was fed the gluten ration and the other the non-gluten ration continuously. Group III received the herd ration continuously, while Groups I and II were subjected to reversal feeding.

The reversal feeding project was divided into three periods of twenty days each for Groups I and II, with two five-day and one eleven-day transition periods. Group I was started on the gluten ration, shifted to the no-gluten ration, and finally returned to the gluten ration, while Group II followed just the opposite course. The entire trial covered 81 days.

The results are given in Table 1 and Table 2.

The reversal fed groups gave no evidence whatsoever of any influence of corn gluten upon the titratable acidity of milk.

The animal fed the gluten ration continuously for 81 days showed a steady increase in titratable acidity from 0.184 per cent in the preliminary

TABLE 1

Effect of feeding corn gluten on the titratable acidity of milk

	GROUP ONE		GROUP TWO		CONTROL GROUP	
PERIOD	Ration	Acidity	Ration	Acidity	Ration	Acidity
		per cent		*per cent*		*per cent*
Prior	Herd	0.190	Herd	0.190	Herd	0.182
1st	Gluten	0.189	No-gluten	0.196	"	0.184
2nd	No-gluten	0.188	Gluten	0.197	"	0.187
3rd	Gluten	0.186	No-gluten	0.196	"	0.183

TABLE 2

Effect of continuous feeding of corn gluten on the titratable acidity of milk

PERIOD	GLUTEN MIXTURE	NO-GLUTEN MIXTURE
	Acidity	Acidity
	per cent	*per cent*
Prior	0.184	0.180
First	0.190	0.178
Second	0.194	0.175
Third	0.197	0.169

period to 0.197 per cent during the third period. The animal fed the no-gluten ration continuously showed a steady decrease in titratable acidity from 0.180 to 0.169 per cent. The results with these two animals point to gluten feed influence, since the milk of the one on high gluten feed steadily increased in acidity while the one on no-gluten feed gave steadily decreasing readings of acidity, both having been changed from a herd ration containing a moderate amount of gluten feed. This result led to arrangements for a second trial.

SECOND TRIAL

To check the effect of protracted high gluten feeding, two Ayrshires, two Jerseys and two Holsteins were selected and divided into two groups, as follows:

Group I—An Ayrshire, a Jersey and a Holstein, fed continuously on a gluten feed mixture

Group II—An Ayrshire, a Jersey and a Holstein, fed continuously on a no-gluten feed mixture

The animals of each breed were paired. Due to unavoidable conditions the two Ayrshires were removed from the experiment after forty-seven days.

The gluten feed mixture consisted of 70 per cent corn gluten feed, 5 per cent standard wheat bran, 5 per cent (42 lb.) ground oats, 20 per cent white hominy feed, and contained 22.19[1] per cent crude protein.

The no-gluten ration consisted of 40 per cent linseed oil meal (O. P.), 20 per cent standard wheat bran, 20 per cent (42 lb.) ground oats, 20 per cent white hominy feed, and contained 23.38[1] per cent crude protein.

Each of the above rations contained an additional one per cent steamed bone-meal and one per cent sodium chloride.

The feeding and milking routine were the same as in the first trial. The milk samples were brought to the laboratory and titrated with N/10 NaOH within two hours after milking instead of in the milk room immediately after milking as in the previous trial.

The results of the second trial are summarized in Table 3, the data for each period representing the average titratable acidity for thirty days.

TABLE 3

Gluten feed and the titratable acidity of milk

PERIOD	NO-GLUTEN MIXTURE			GLUTEN MIXTURE		
	Ayrshire	Jersey	Holstein	Ayrshire	Jersey	Holstein
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Prior	0.187	0.165	0.188	0.166	0.178	0.158
First	0.183	0.165	0.180	0.160	0.169	0.162
Second	0.182	0.167	0.178	0.160	0.173	0.163
Third		0.162	0.178		0.176	0.158
Fourth		0.161	0.181		0.174	0.168
Fifth			0.175			0.159
Days	47	118	131	47	118	131

In the second trial there was no observable trend in the apparent acidity of either group. There were differences in the individual behavior of the animals but nothing that can be translated into terms of group response.

DISCUSSION

A study of the results indicates that feeding corn gluten feed in relatively large amounts did not increase the titratable acidity of the milk.

The percentage of acidity of the milk from twenty-nine animals in the herd, free from mastitis and apparently normal in other respects, was 0.190 with a standard deviation of $\pm$ .015, a reading that would subject their milk to rejection. It is an established fact, observed in this study also, that

[1] Analysis made by the Connecticut (New Haven) Experiment Station.

the fresh milk of breeds producing milk of high solids content is relatively higher in titratable acidity than is the milk of lower solids-yielding breeds.

CONCLUSIONS

Two trials were conducted, one over a period of 81 days and another over periods of 47, 118 and 131 days, to compare the titratable acidity of fresh milk from cows whose grain rations varied from no-gluten feed to 20 per cent gluten feed (herd ration) and 70 per cent gluten feed by weight.

The results of the two trials indicate that corn gluten feed in the ration is not a factor which influences the titratable acidity of milk.

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THE EFFECT OF THE ADSORPTION "MEMBRANE" AROUND THE FAT GLOBULES ON THE CURD TENSION OF COW'S MILK*

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According to Lundstedt (1) the relatively low curd tension exhibited by buttermilk is caused by the adsorption on the casein of the lecithin removed from the fat globules during churning. In support of this hypothesis Lundstedt shows (1) that the curd tension of the skim milk fraction of mixtures of skim milk and whipped cream varies inversely with the rise in the cream fraction; (2) that there is a coincident rise in the lecithin which may be extracted from the casein precipitated from the skim milk by HCl. In further support of his hypothesis Lundstedt asserts that whole milk which has been agitated at low temperature exhibits a greatly reduced curd tension because of the removal of sufficient lecithin from the fat globules during the treatment. Indeed, he has been granted a patent (2) for thus producing soft-curd milk.

It is obvious that Lundstedt's lecithin data lack the crucial test of observing the effect of the direct addition of lecithin to milk. We were fortunate in having available for such a test a quantity of unoxidized phospholipide complex[1] prepared from egg yolk. When we failed to secure a reduction in curd tension either through adding this phospholipide to milk or by agitating milk at low temperature, whereas it was found that sweet cream buttermilk does show a reduced curd tension it seemed obvious that further experiments as well as another hypothesis were required to explain the latter result. This paper reports some of the additional studies we have made of this problem.

EXPERIMENTAL

General methods employed.—Curd tension data, being obtained by an empirical procedure, are not to be regarded as absolute values. In our studies the data are comparable only in experiments involving the same sample[2] of milk and the same coagulant. In certain experiments the Hill

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[1] The phospholipide complex was a mixture of pure lecithins and cephalins containing approximately 80 to 85 per cent lecithins, prepared by the method of Sueyoshi (3) as modified by H. B. Bull and V. L. Frampton (4) of the Division of Agricultural Biochemistry of the University of Minnesota. The product was a colorless, paraffin-like wax readily dispersable in aqueous media to form colloidal sols.

[2] The milk for these experiments was in all cases fresh raw mixed milk from the Minn. Agr. Experiment Station dairy herd. Preliminary study using the Hill coagulant showed

(2) coagulant (pepsin-$CaCl_2$) was used, in others pepsin alone, in others rennet extract. In all experiments sufficient coagulant was used to cause

TABLE 1

Effects on curd tension of adding phospholipides to whole milk and skim milk

EXP. NO.	METHOD OF ADDING LECITHIN	CURD TENSION[1]					
		WHOLE MILK			SKIM MILK		
		BLANK	CONTROL	LECITHIN ADDED	BLANK	CONTROL	LECITHIN ADDED
		grams	*grams*	*grams*	*grams*	*grams*	*grams*
1a (initial)	trituration and emulsifying	60	62	61	95	> 104	> 102
1a (24 hrs.)	trituration and emulsifying	75	69	68	92	88	88
1b (initial)	addition of aqueous sol	.....	.....	.....	95	82	91
1b (24 hrs.)	addition of aqueous sol	.....	.....	.....	.....	79	80
2	trituration, emulsifying and agitation at low temp.	.....	.....	.....	98	88	91

[1] Using Hill coagulant for experiment 1 and pepsin alone for experiment 2.

clotting within one-half minute. Other conditions were in accordance with the standard Hill test, except that the older curd knives (diam. 2 inches) and the special Chatillon spring balance were employed. The data reported are the average of duplicate or more readings agreeing within approximately 10 per cent, usually within much closer range (except for high curd tensions for which exact duplicates are difficult by the knife method). Hydrogen ion concentrations when determined were usually by the electrometric method, using the Bailey electrode except where indicated. Special procedures are described in connection with the several experiments.

Effect of adding phospholipide to milk.—Two experiments were conducted involving the direct addition of pure phospholipides to milk. In the first experiment a comparison was made of adding the phospholipide by two methods; (a) trituration of the waxy solid in a mortar with a small volume of the milk, addition of this preparation to the larger volume of milk on which curd tension was to be determined and passage of this mixture once through a hand emulsifier;[3] (b) addition of an aqueous sol[4] of the

that this milk had a curd tension of 65–70 grams under the conditions employed, the skim milk showing values from 90 to 100 grams. With rennet extract as coagulant the values were about 30 per cent lower.

[3] A Club Aluminum Products Co., 12 oz. hand "homogenizer" was found suitable for this purpose.

[4] The volume of water employed was 15 ml. added to 300 ml. milk.

lecithin to the milk. The experiment also involved the effects of the phospholipide on both whole milk and skim milk and the effect of aging the mixes for 24 hrs. at 5° C. Blank curd tensions were run on untreated portions of the whole milk and skim milk, and also "controls," *i.e.*, samples of whole milk and skim milk which had the same treatment as the experimental samples other than the addition of phospholipide. In one experiment this involved trituration of a small portion of the milk in a mortar and passage of the entire milk through the emulsifier, and in the other experiment the addition of water equal to that added in the aqueous phospholipide sol. Sufficient phospholipide was used to give a concentration of 0.35 per cent of added product in the final milk.

The second phospholipide experiment was conducted with skim milk. The object was to determine whether the lack of effects secured in experiment 1 could have been due to an oxidation of the phospholipide complex and/or a failure to allow the phospholipide sufficient opportunity to be adsorbed by the casein. Since phospholipide seems to be readily adsorbed by the fat globules it seemed advisable to limit this experiment to skim milk in order to avoid any competition between the casein and the fat globules for the added phospholipide. For these purposes the colorless, waxy phospholipide was taken directly from the acetone in which it was suspended, dried between filter papers, weighed rapidly, triturated to a colloidal sol in a small volume of warm skim milk and transferred to a large volume of skim milk which was then passed through the hand emulsifier; the emulsified mixture was cooled to 4° C. and churned for 60 minutes in a glass Dazey churn and then allowed to stand over night at 5° C. This experiment also involved a "blank," which had merely been kept cold and a "control" which had been carried through all the mechanical treatments without the addition of phospholipide. Sufficient phospholipide was employed in this experiment to give a 0.575 per cent concentration in the final milk. This is nearly twice the maximum phospholipide concentration in buttermilk reported by Holm, Wright and Deysher (5).

The results of these experiments are shown in table 1. No important changes are noticeable, which are not likewise shown by the control samples.

Effects of churning and of agitation at low temperature.—Three experiments were conducted to compare the curd tension of various samples of whole milk, skim milk, buttermilk and agitated[5] whole and/or skim milk when these various products originated from the same lot of fresh whole milk. The curd tension determinations were repeated on the buttermilk after standing for several days at 5° C. to ascertain whether the reduced curd tension is permanent. Tarassuk and Richardson (6) have observed

[5] The agitation experiments were carried out in glass Dazey churns immersed in a water bath at the desired temperature, the agitation exceeding normal churning speed.

that the reduction in curd tension of milk following homogenization at pressures of 1,500 to 2,500 lbs. at 100° F. is partially restored on standing.

The results are shown in Table 2. It is evident from these data that buttermilk shows a definitely and permanently reduced curd tension, in comparison with both its corresponding whole milk and skim milk but that this effect is not duplicated by the agitation of milk; in fact the only apparent reduction due to agitation occurred in samples of separator skim milk (exps. 1 and 3) which contained no fat globule "membrane" substances. Agitation experiment 1 (b) was conducted on samples of the same milk fractions as experiment 1 (a) after having stood in the cold room for 24 hours.

TABLE 2

Comparative curd tensions of whole milk, skim milk, buttermilk and the effect of incipient churning

EXP.	SAMPLE	CURD TENSION[1]
		grams
1 (a)	Original whole milk[2]	70
	Skim milk	> 103
	Buttermilk[3]	47
	Buttermilk after 60 hours standing	49
	Whole milk agitated at 20° C. for 22 min.	73
	Skim milk " " " " " "	90
1 (b)	Whole milk agitated at 5° C. for 22 min.	82
	Skim milk " " " " " "	> 101
2	Original whole milk	74
	Buttermilk	55
	Buttermilk after 60 hours standing	50
	Whole milk agitated at 5° C. for 50 min.	73
	Agitated whole milk after 60 hours standing	66
3	Skim milk	90
	Buttermilk	44
	Skim milk agitated at 4° C. for 60 min.	88

[1] Using Hill coagulant.

[2] pH 6.66.

[3] pH 6.59.

Effect of fat globule "membrane" complex on curd tension.—Palmer and Samuelsson (7) and Palmer and Wiese (8) have shown that the natural fat globule "membrane" of cows milk which is released during the churning of cream, is a phospholipide-protein complex which is not coagulated by rennet. Preliminary tests showed that a concentrated sol of crude "membrane," prepared from the buttermilk of churned, washed cream, would lower the curd tension of a skim milk control[6] below that of its

[6] The skim-milk control was diluted with the same volume of water as that of the concentrate of "membrane" material, but no water was added to the corresponding whole milk.

corresponding whole milk. The following is a typical result when using the Hill coagulant.

Curd tension of skim milk control	77 grams
Curd tension of whole milk	72 grams
Skim milk plus "membrane" sol	58 grams

Further preliminary tests showed tthat it is necessary to employ freshly prepared and carefully concentrated "membrane" sols in order to demonstrate their optimum curd-tension reducing properties.

Two principal experiments were conducted. In general both consisted of a comparison of curd tensions of skim milk following the addition of either concentrated "membrane" complex or concentrated plasma solids. Both experiments also involved a number of suitable controls. For example, in both experiments we compared the curd tension of a natural buttermilk and that of a buttermilk from a sample of the same cream which had been thoroughly washed with water and then rewashed with skim milk. Also in both experiments an attempt was made to control the "solids" added to the skim milk as "membrane" complex concentrate or plasma concentrate, respectively. The experiments differed primarily in the nature and extent of this control. In the first experiment the control was somewhat crude in that the plasma concentrate consisted of a sample of skim milk in which one per cent fat had been emulsified and the low-fat "synthetic" skim concentrated by pervaporation[7] to the total solids content of the "membrane" complex concentrate, *i.e.*, about 30 per cent. In the second experiment the plasma concentrate consisted of a sample of dialyzed skim milk, essentially free from lactose and soluble salts, in which butterfat was emulsified to give the same fat/solids-not-fat ratio[8] as the buttermilk from the washed cream. This was diluted with distilled water to the total solids content of the washed cream buttermilk and the two sols pervaporated at the same time to the same concentration (approximately one-tenth the original volume). Both experiments had as controls the curd tension of the untreated skim milk from the original lot of whole milk and which was likewise used for washing the creams following the water-washing.

The "membrane" complex was prepared in each case by washing fresh 35–40 per cent cream four times, each with four volumes of distilled water at 100° F., and churning this cream.

[7] The material is put in 12–15 inch lengths of 18–20 mm. (diam.) Visking casings which are tied at both ends and suspended over an electric hot plate toward which an electric fan is directed. This method of evaporating colloidal sols without heat treatment is rapid and efficient. It has been used for many years in this laboratory and was first described in principle by Kober (J. Am. Chem. Soc. 39: 944, 1917).

[8] The fat content employed was based on the "true" fat content of the buttermilk from the washed cream, which was determined by the Minnesota Babcock method, using the Minnesota reagent.

The results are shown in Table 3, which also shows the composition of the concentrates added to the skim milk fractions. There can be no ques-

TABLE 3

Curd tension of skim milk before and after addition of colloidal concentrates of fat globule "membrane" and milk plasma (natural and dialyzed) in comparison with curd tension of natural buttermilk and buttermilk from cream washed with water and rewashed with skim milk

EXPERIMENT	PRODUCT TESTED	CURD TENSION[1]	VOLUME OF CONC. ADDED	COMPOSITION OF CONCENTRATE		
				TOTAL SOLIDS	FAT	SOLIDS-NOT-FAT
		grams	*per cent*	*per cent*	*per cent*	*per cent*
1	Original skim milk	61	.....	.....	.....	.....
	Natural buttermilk	39	.....	.....	.....	.....
	Buttermilk from cream rewashed with skim milk	44[2]	.....	.....	.....	.....
	Skim milk plus "membrane" conc.	42	10.0	28.4	.....	.....
	Skim milk plus plasma conc.	>100	10.0	31.2	.....	.....
2	Original skim milk	60[3]	.....	.....	.....	.....
	Natural buttermilk	34	.....	.....	.....	.....
	Buttermilk from cream rewashed with skim milk	39	.....	.....	.....	.....
	Skim milk plus "membrane" conc.	39[4]	7.6	9.52	1.04	8.48
	Skim milk plus plasma colloid conc.	65[5]	7.6	9.46	2.08	7.38

[1] Using rennet extract.
[2] Using Hill coagulant.
[3] pH 6.33.
[4] pH 6.34 (quinhydrone).
[5] pH 6.30 (quinhydrone).

tion that these data demonstrate conclusively the curd-tension reducing effect of the "membrane" complex. In experiment 1 the amount of concentrated solids-not-fat added to the skim milk undoubtedly increased the solids-not-fat of the skim milk, as evidenced by the very high curd tension of the skim milk containing added plasma concentrate, and yet the curd tension of the skim milk containing added "membrane" concentrate was essentially the same as that of the natural buttermilk. In experiment 2 the solids-not-fat of the skim milk were slightly diluted (5% or less) by the concentrates, but the curd tension of the skim milk with added "membrane" was much lower than could be accounted for by so slight a dilution, and the curd tension of the skim milk with added plasma colloid concentrate

was actually increased slightly (as would be expected). Further proof of the curd tension reducing effect of "membrane" complex is seen in the reduced curd tensions of the buttermilk from the creams which had been washed with water and the water replaced by skim milk in a subsequent washing. The curd tension of these buttermilks was essentially the same as that of the natural buttermilk from other portions of the same creams.

Effect on curd tension of "membrane" adsorbed by fat globules emulsified in buttermilk from washed cream.—Having demonstrated that it is the natural fat globule "membrane" complex released during churning which is responsible for the lower curd tension of buttermilk we sought to determine whether butterfat globules will readsorb this complex from the buttermilk of washed cream and release it again into normal milk plasma (skim milk) and cause a reduction in the curd tension of the buttermilk thus produced.

Fresh, sweet cream, containing 35 per cent fat, was washed four successive times, each with four volumes of distilled water at 100° F. After standing over night at 5° C, the temperature was raised to 12° C. and the cream churned. The free buttermilk was warmed to 38° C. and sufficient fat emulsified with it to produce an artificial 35 per cent cream. The emulsification was carried out by means of the hand homogenizers,[9] producing a stable emulsion. This was diluted with fresh skim milk to a fat content of 3.8 per cent. A portion was saved for curd tension tests and the remainder separated into a "remade" cream and a "remade" skim milk. The cream tested 25 per cent fat. A portion of the skim milk was saved for curd tension tests. The separation was carried out with the laboratory Sharples supercentrifuge geared down to 12,000 r.p.m. In order to secure a normal separation a portion of normal whole milk was first passed through the centrifuge. The first skim milk and cream portions corresponding to the volume of normal whole milk used, were discarded. Portions of the "remade" skim milk were saved for curd tension. The "remade" cream thus obtained churned normally in 40–45 minutes after proper temperature adjustment. The "remade" buttermilk from this churning was saved for curd tension tests. Analyses of this buttermilk showed 0.3 per cent fat and 8.2 per cent total solids. The curd tension results are shown in Table 4 in comparison with the curd tension of portions of skim milk and buttermilk from the original cream.

The data are a remarkable demonstration of both the emulsifying properties of the "membrane" complex and its rôle in determining the decreased curd tension of buttermilk. It may also be remarked that although

[9] The material was passed through the two-quart two-cylinder Club Aluminum Products Co. "homogenizer" and once through their 12 oz. "homogenizer." Microscopic examination showed a fairly normal fat globule size although there were some globules considerably larger than found in normal milk.

TABLE 4

Curd tension of "remade" milks (whole, skim milk and buttermilk) involving the use of a synthetic cream made by emulsifying butterfat in the buttermilk from churned washed cream

PRODUCT TESTED	CURD TENSION[1]	
	1ST TEST	2ND TEST 24 HOURS LATER
	grams	*grams*
Original skim milk	78	67
Original buttermilk	41	.....
"Remade" whole milk	58	61
"Remade" skim milk	79	77
"Remade" buttermilk[2]	43	45

[1] Using rennet extract as coagulant. [2] pH 6.22.

the experiment cannot be offered as proof that no denaturing of the natural "membrane" occurs during churning it is very evident that any denaturization which does occur is insufficient to seriously affect its emulsifying properties and apparently has no effect on the influence the complex exerts on curd tension.

Effect on curd tension of "membrane" adsorbed by fat globules emulsified in skim milk.—The foregoing experiment suggested the possibility of determining whether butterfat globules will adsorb any material from skim milk which, when released during churning, will lower the curd tension of the "buttermilk." Two experiments were carried out employing the same general procedure as in the preceding experiment. For comparative purposes samples were saved of original whole milk, its skim milk fraction and buttermilk from churning a portion of the original cream. Melted, filtered butterfat was emulsified in another portion of the skim milk to form a cream, this was diluted with the skim milk to the fat content of normal whole milk, the latter reseparated and the cream churned, samples of the "remade" whole milk, skim milk and buttermilk being saved for curd tension tests.

The two experiments differed chiefly in that only one emulsification was employed in making the synthetic skim-milk cream in the first trial whereas the fat and skim milk mixture were put through the hand "homogenizer" four times in the second trial; also samples of original whole milk, skim milk and buttermilk were not saved for curd tension tests in the second trial. The composition of the products made in the two experiments was as follows:

	1st trial	2nd trial	
	Fat	Fat	Solids-not-fat
	per cent	*per cent*	*per cent*
"Remade" cream	29.5	33.0	.....
"Remade" whole milk	4.4	4.2	.....
"Remade" skim milk	.....	0.15	9.05
"Remade" buttermilk	.....	1.50	9.40

Previous experience in this laboratory has shown that dilute emulsions made from butterfat and skim milk do not separate as readily as normal milk and the cream thus obtained churns with difficulty, showing large losses of fat. These difficulties were experienced in the present trials. The churning time for the cream in the first trial was 3 hours and for the second trial 1 hr. 10 min.

The curd tension data are shown in Table 5. The results of the two experiments are in harmony in showing that buttermilk produced in the

TABLE 5

Curd tension of "remade" milk (whole, skim milk and buttermilk) involving the use of a synthetic cream made by emulsifying butterfat in skim milk

PRODUCT TESTED	CURD TENSION[1]	
	1ST EXP.	2ND EXP.
	grams	*grams*
Original whole milk	45	.....
Original skim milk	57	.....
Original buttermilk	31	.....
"Remade" whole milk	56	72
"Remade" skim milk	59	74
"Remade" buttermilk	58	94

[1] Rennet extract used for coagulant.

churning of cream synthesized from butterfat and skim milk has the same or even higher curd tension as the skim milk. It is unfortunate that the fat content of the "remade" buttermilk was not determined in experiment 1; it may have been much greater than for experiment 2 in which there is evidence that the plasma solids adsorbed by butterfat from skim milk are those which tend to cause higher curd tension. The curd strength of this buttermilk was surprisingly high in view of the high fat content.

These results furnish further evidence of the rôle of the natural fat globule "membrane" complex in the decreased curd tension of natural buttermilk. They also serve to substantiate the fact that milk plasma does not furnish the constituents which stabilize the natural milk emulsion.

Effect on curd tension of "membrane" adsorbed by fat globules emulsified in whey.—Rimpila and Palmer (9) have found that the composition of the adsorption "membrane" around the fat globules of an artificial cream made by emulsifying butterfat in whey is different from that of an analogous skim-milk cream; the proportion of protein per 100 grams of fat

is essentially the same being 650 mgm. for the skim-milk cream and 570 mgm. for the whey cream but the whey cream contains relatively much more phospholipide, as estimated from the lipide P per 100 grams of fat, i.e., 0.66 mgm. in contrast to 0.14 mgm. for the skim-milk cream. (These comparisons are based on creams washed three to four times). Natural creams, after analogous treatment, contain on the average approximately 620 mgm. protein and 10 mgms. lipide P per 100 grams fat.

Three experiments were conducted to test the effect on curd tension of the adsorption "membrane" released into skim milk from the emulsion formed by dispersing butterfat in fresh, sweet rennet whey. The procedure employed in preparing the products differed slightly in the three trials but it will be sufficient to describe the first trial and point out how the other two differed from it.

Whey was prepared from fresh skim milk by adding 2.5 ml., 1 to 50 dilution of Hansen's rennet extract to 1600 ml. milk, at 35° C. The time of clotting was 30 minutes. The whey removed equaled 1140 ml. Artificial cream was prepared by emulsifying 400 ml. melted butterfat with this volume of whey at 37° C., passing the mixture 4 times through the 2-quart Club Aluminum Co. hand "homogenizer." This cream was washed immediately with 4 volumes of water yielding 820 ml. of washed cream. This was diluted to a "remade" whole milk of 5,466 ml. using the original skim milk. This milk was separated to yield the "remade" skim milk and a "remade" cream, containing 30 per cent fat. The latter was allowed to stand over night at 5° C., brought to churning temperature and churned to yield the "remade" buttermilk. Churning required 1 hr. 20 min. The procedure in the second trial differed in the following details: The fat-whey mixture was passed through the "homogenizer" 5 times; the cream was allowed to stand 3.5 hours at 5°–10° C. before washing; the washing consisted of a single washing with 4 volumes of water, followed by a washing with 4 volumes of skim milk before being diluted with the skim milk to make the "remade" whole milk. In the third trial the emulsification was carried out 4 times and the washing with water and skim milk followed immediately. The "remade" cream, containing only 23.5 per cent fat, required 2 hrs., 20 min. to churn.

The results of the whey-cream experiments are shown in Table 6. It is evident that butterfat globules adsorb substances from whey which exert the same effect on curd tension as the natural fat globules "membrane" materials. In the second trial the curd tension reduction was much greater than observed in any of the "natural" membrane experiments. The explanation of this must await further study. This trial differed from the others only in that the first synthetic cream was allowed to stand for several hours at low temperature before it was washed. The low curd tensions of

TABLE 6

Curd tension of "remade" milk (whole, skim milk and buttermilk) involving the use of a synthetic cream made by emulsifying butterfat in whey

EXPERIMENT	PRODUCT TESTED	CURD TENSION[1]	FAT	TOTAL SOLIDS	SOLIDS-NOT-FAT
		grams	*per cent*	*per cent*	*per cent*
1	"Remade" whole milk	63	3.80	.....	.....
	"Remade" skim milk	74	0.06	8.46	8.40
	"Remade" buttermilk	52	0.40	8.87	8.44
	Original skim milk	85	.....	.....	.....
2	"Remade" whole milk	64	.....	.....	.....
	"Remade" skim milk	72	0.06	8.76	8.70
	"Remade" buttermilk	10	> 0.50	9.42	.....
	Original skim milk	77	0.06	9.27	9.21
3	"Remade" whole milk	65	3.50	.....	.....
	"Remade" skim milk	77	0.06	9.50	9.44
	"Remade" buttermilk[2]	44	0.70	9.72	9.02

[1] Using rennet extract as coagulant.

[2] pH of this buttermilk 6.24.

these "remade" buttermilks are clearly not related either to their gross composition or to their acidity.

DISCUSSION

The curd tension of natural buttermilk from sweet cream is approximately 70 per cent of that of the corresponding whole milk and about 50 per cent of that of the corresponding skim milk. Although this reduced curd tension is in line with Lundstedt's general observation we obtained no values as low as 7 grams, which Lundstedt reported. Contrary to Lundstedt's claims no effect on curd tension appears to follow the agitation of whole milk at low temperature. Either some other unrecognized factors entered into his experiments or his results were fortuitous. Lundstedt's hypothesis explaining the reduced curd tension of buttermilk (and agitated whole milk) as due to the adsorption by casein of lecithin released from the fat globule during churning is not substantiated by dispersing pure phospholipides in milk in concentrations equal to or greater than the lecithin content of buttermilk and further by providing the conditions for its maximum adsorption by the colloidal caseinate, namely mechanical emulsification at body temperature, agitation at low temperature and aging at low temperature.

The question may arise in the minds of some as to the validity of employing for these studies a phospholipide isolated from egg yolk. It may be stated in explanation that there are as yet no grounds for believing that lecithin from one source differs essentially in colloidal properties from lecithin from another source, although differences in chemical constitution

are not only probable but are to be expected. Our primary concern in this phase of the study was to employ pure phospholipide, unoxidized and uncontaminated with the impurities which abound in the so-called lecithin preparations from eggs and soybeans employed in technical dairy product manufacturing operations.

The criticism might also be advanced that the lecithin which we employed was contaminated with 15–20 per cent cephalin. This criticism is invalidated by the recent finding of Spiegel-Adolph (10) that cephalin is much more readily adsorbed by colloidal gold, protein and cholesterol than is lecithin. Our phospholipide may therefore be regarded as probably being a "stronger" colloid than if it had actually been pure lecithin.

Lundstedt's hypothesis somewhat approaches the correct explanation, however, in that it is definitely demonstrated that the natural phospholipide-protein complex on the fat globule surfaces which is released during churning, is responsible for the reduced curd tension of buttermilk. Artificial buttermilks prepared by the direct addition to milk of a concentrated sol of this complex, and "buttermilks" obtained by churning "remade" creams formed by diluting washed cream with skim milk and reseparating, exhibit curd tensions as low as those of natural buttermilk. Even when the cream is more artificial, namely, is made by emulsifying butterfat in the buttermilk from washed cream, and then dispersing this cream in normal milk plasma, the final "buttermilk" likewise shows a low curd tension. On the other hand synthetic creams involving only butterfat and skim milk produce "buttermilks" having curd tensions equal to or greater than the skim milk.

A peculiar appearance and a decided non-foaming tendency characterized all the buttermilks and also the whey from the curd tension tests whenever the natural fat globule membrane complex was present. These wheys especially have a characteristic brownish tint not seen in whey from skim milk. Moreover, concentrated sols of the membrane complex have a similar tan color. This color is not evident in the curd-test wheys from the artificial products involving butterfat emulsions in skim milk and in whey.

The reduced curd tension of the "buttermilk" obtained from the emulsions in rennet whey was unexpected. It is apparent that the phospholipide complex adsorbed from whey by the butterfat globule surfaces reduces the curd tension of milk plasma in the same manner as the natural fat globule membrane. However, the fact that this complex contains only about 7 per cent as much phospholipide as the natural "membrane" complex, according to the data of Rimpila and Palmer (9) seems to point to the protein of the complex as the major curd tension reducing agent. This aspect of the problem, as well as the explanation of how this small amount of foreign

material exerts such a marked effect on curd tension are being investigated further. The authors wish to reserve this problem for study.

CONCLUSIONS

The relatively low curd tension of fresh sweet-cream buttermilk is not explained by the release of lecithin from the fat globule surfaces during churning. Instead, it is the release of the fat globule "membrane" complex which is the factor involved. The exact cause of the lowered curd tension when this material is added to milk remains to be discovered.

Agitation of whole milk at temperatures below that of churning does not cause the milk to have a reduced curd tension.

Butterfat globules do not adsorb any substances from skim milk which reduce the curd tension of milk plasma.

Butterfat globules adsorb some complex from normal rennet whey which reduces the curd tension of milk plasma. The relatively low phospholipide content of the adsorption "membrane" complex of whey-cream suggests that the protein component is the major one concerned in its effect on curd tension. This may also be the case for the natural fat globule "membrane."

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DETECTING RECONTAMINATION OF PASTEURIZED MILK BY BACTERIOLOGICAL METHODS*

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INTRODUCTION

The primary objects of pasteurization of milk are to (1) destroy any pathogenic organisms which may be present and (2) prolong keeping quality. These aims are defeated if recontamination occurs following pasteurization. Therefore, methods which will detect recontamination are important for workers entrusted with maintaining the quality of pasteurized supplies.

Plant inspections may not disclose sources of recontamination since they may be made at a time when faulty conditions are not apparent. Also, a routine examination of street samples by means of standard agar plate counts is of little value in this respect since there is no way of determining whether or not high bacterial counts are due to recontamination or other conditions.

An examination of a series of plant samples taken at various points of processing is valuable in detecting recontamination particularly if the first milk passing over the equipment is sampled. Recently, there has been a tendency to supplement the standard agar plate count with a count of organisms of the colon group. Among the reports on this subject should be mentioned the work of McCrady and Langevin (1). They found that the presence of organisms of the colon group in pasteurized milk sometimes reveals sources of contamination that standard agar plate counts do not show since a relatively small increase in the number of colon organisms could be detected while no appreciable change was apparent in the standard plate count. By means of the test for colon organisms, they were able in one instance to detect a potentially dangerous source of contamination that plant inspection did not reveal.

In the present study, a routine monthly examination of process samples taken at two plants indicated post-pasteurization contamination in the case of one plant. The success in locating sources of recontamination and in correcting faulty conditions was such that the results obtained should be of interest to workers in this field.

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METHODS

The number of colon organisms per cc was estimated by means of plate counts from a lactose desoxycholate agar (2) of the following composition:

Agar	15 grams
Proteose peptone	10 "
Sodium desoxycholate*	1 gram
Sodium chloride	5 grams
Dipotassium phosphate	2 "
Lactose	10 "
Ferric ammonium citrate (green scales)	2 "
Distilled water	1000 cc
pH	7.4

The agar was placed in flasks in 200 cc amounts and partially sterilized by flowing steam for 30 minutes. Absolute sterilization by steam under pressure is not necessary in the case of this medium since spore-forming rods will not grow. One cc and one-tenth cc quantities of milk were plated with 12 to 15 cc of the above medium, poured before the milk dried to the plate. After solidification, about 3 cc of agar were poured over the surface to secure entirely subsurface colonies as earlier work had shown that this facilitated identification of colon colonies. Plates were incubated 20 to 24 hours at 37° C. and the deep red colon colonies counted. One colony of each type was usually transferred to lactose broth and tubes showing gas were streaked on eosine methylene blue agar for partial confirmation. In the case of the plants studied, deep red colonies on the plates from pasteurized milk always confirmed as colon colonies.

RESULTS OBTAINED

Both plants had pasteurizing runs of about three hours. Plant A employed the Electropure system of high-temperature, short-time pasteurization using a pasteurizing temperature of 162°–163° F. and a holding time of 15–20 seconds. Plant B employed three Pfaudler glass-lined pasteurizers using a pasteurizing temperature of 143°–144° F. for 30–40 minutes. The customary procedure was to preheat the raw milk entering the pasteurizer to 110°–130° F. and to then raise the temperature to 143° in the vat.

A series of process samples were taken at the start, middle and end of the run at plant A and from four different batches at plant B. Samples of pasteurized milk were taken at four points between the pasteurizer and the bottler in the case of each series at plant A and the first series at plant B. Subsequent series of samples at plant B were taken from only the raw and the freshly pasteurized milk. The presence or absence of organisms of the colon group in 1 cc quantities of milk is shown in Table 1. Organisms of the colon group were present in 1 cc quantities of raw milk in 63 samples out

* Obtained from Riedel-de Haen, Inc., 105 Hudson St., New York.

of 68 in numbers ranging between 1 per cc and 13,000 per cc. During the winter months, the number of organisms of the colon group was usually less than 100 per cc.

Colon organisms were not found in 1 cc amounts of freshly pasteurized milk in any of the 77 instances (includes 30 samples taken at cooler inlet at plant A since the holding time takes place as the milk flows between the Electropure unit and the cooler). This shows that colon organisms failed to survive pasteurization temperatures. At plant A, positive results were not obtained from samples taken at the cooler outlet, bottler bowl or of the first milk over the cooler indicating that there was no recontamination of the pasteurized milk.

TABLE 1

Presence of organisms of the colon group in 271 samples of raw and pasteurized milk taken monthly for one year at two plants

PLANT	PRESENCE OR ABSENCE OF LARGE RED COLON COLONIES ON PLATES FROM 1 CC QUANTITIES OF MILK											
	Raw milk		Pasteurized milk									
	Supply tank		Pasteurizer		Cooler inlet		Cooler outlet		Bottler bowl		First milk over equipment*	
	+	−	+	−	+	−	+	−	+	−	+	−
A	30	0	**	**	0	30	0	30	0	30	0	30
B	33	5	0	47	2	10	**	**	5	7	8	4

* Represents the first can of milk drawn off between the cooler and bottler bowl at plant A and from the bottler bowl at plant B.

** No samples taken.

The practice of pumping hot water through the line for 5 minutes at 180° F. just prior to pasteurization evidently caused the destruction of any colon organisms present on the equipment.

Recontamination of pasteurized milk took place at plant B as evidenced by presence of organisms of the colon group in some of the samples taken at the cooler inlet, from the bottler bowl and of the first milk over the equipment. More positive results were obtained in the case of the first milk over the equipment (8 out of 12) than in the case of the samples from the cooler inlet (2 out of 12) or from the bottler bowl (5 out of 12) indicating that the equipment was contaminated.

There is no object in testing for the presence of organisms of the colon group if the standard plate count will detect recontamination just as readily. Comparative standard agar plate counts and plate counts of colon organisms for the first series of samples taken at plant B are shown in Table 2. Counts of raw and preheated milk are omitted since they are not of interest in connection with this problem.

Standard agar and colon counts of the first milk over the equipment were usually higher than those of milk sampled later from the cooler inlet and from the bottler bowl (Table 2). In 8 of the 12 monthly tests, colon organ-

TABLE 2

Comparative standard agar plate counts and plate counts of colon organisms per cc. Obtained from monthly processing samples at Plant B

DATE 1934–35	SOURCE OF SAMPLE							
	Pasteurizer		Cooler inlet		Bottler bowl		First over equipment	
	Total count	Colon count	Total count	Colon count	Total count	Colon count	Total count	Colon count
October	4100	<1	4900	1	4300	2	44000	78
November	2000	<1	3200	9	1800	32	1500	23
December	3500	<1	3900	<1	2500	<1	3300	<1
January	5800	<1	4700	<1	6000	<1	19000	13
February	4800	<1	7500	<1	3900	<1	3000	<1
March	4700	<1	4800	<1	5400	13	8600	<1
April	4700	<1	3100	<1	5200	<1	53000	<1
May	4200	<1	2800	<1	3200	<1	7200	50
July	300	<1	3600	<1	13000	4	54000	3
August	14500	<1	16000	<1	12000	<1	83000	3000
September	10800	<1	8000	<1	7500	<1	4300	340
October	2800	<1	29000	<1	2000	3	6000	11

isms were present in the first milk over the equipment. In 4 of the 8 instances, (Oct., Jan., July, Aug.) there was also an appreciable increase in the standard agar plate count indicating that recontamination could be detected as readily by one method as by the other. In the 4 remaining instances out of the 8 (Nov., May, Sept., and Oct.) differences in standard plate counts were too slight to be of significance while the presence of colon organisms in numbers ranging between 11 and 340 per cc in the first milk over the equipment definitely indicated recontamination. In one instance (April), out of the four in which colon organisms were not found, the standard plate count increased from 4700 per cc in the freshly pasteurized milk to 53,000 per cc in the first milk through the equipment indicating recontamination. In this case, recontamination was not detected by the test for colon organisms. This supports the viewpoint of McCrady and Langvin that the test for colon organisms should not supplant but should be used in conjunction with the total count.

Since colon organisms were always absent from 1 cc quantities of the freshly pasteurized milk, it was evident that when recontamination occurred it took place between the pasteurizer and bottler. Ninety-two samples were taken between these points to determine the sources of recontamination (Table 3).

Numbers of colon organisms in the first milk over the equipment varied

TABLE 3

Plate counts per cc of organisms of the colon group obtained from 92 samples of pasteurized milk taken at Plant B in studies of sources of recontamination

DATE 1935	SOURCE OF SAMPLE								
	Pasteurizer	Outlet valve	Pump	Cooler inlet	Cooler outlet	Bottler bowl	Freshly bottled milk	First milk over equipment	Drippings from coupling into bottler
October 2	<1	<1	100	<1	<1	<1	1	40	
October 3	<1	<1	<1	<1	<1	20	10	10	
October 4	<1	150	140	10	10	<1	<1	290	
October 10	<1	7	20	2	10	20	13	160	2600
October 11	<1	240	620	60	30	140	70	1250	
October 15	<1	<1	<1	<1	<1	2	1	1	5000
October 16*	<1	<1	<1	<1	<1	3	1	11	1280
October 17	<1	<1	<1	<1	<1	<1	<1	<1	
October 18	<1	<1	<1	<1	<1	<1	<1	<1	
October 21	<1	<1	<1	<1	<1	<1	1	<1	
October 22	<1	<1	<1	<1	<1	<1	4	<1	
November 1								<1	

* Sources of recontamination and proper sterilization of equipment discussed with plant employees.

between 1 and 1,250 per cc during the period between October 2 and 16 when no effort was made to correct faulty conditions. The pump was the major source of recontamination on October 2, the bottler on October 3 and the outlet valve on October 4, 10 and 11. On October 15 and 16, a few colon organisms were recovered from the milk sampled in the bottler bowl, indicating again that this was a source of recontamination. These results indicated several sources of recontamination.

Observations of plant operations showed that recontamination from the outlet valve was probably due to occasional neglect to steam the milk line leading from the outlet valve before the pasteurized milk was drawn from the vat. A slight amount of partially pasteurized milk ordinarily dripped into the outlet line and ran onto the floor if the cap was left off the end of the line. The operator was instructed by the local inspector to remove this cap and sterilize the line with steam before the outlet valve was opened but was careless in this respect.

In the case of the pump, recontamination with organisms of the colon group was undoubtedly due to growth following improper cleaning and sterilization.

Recontamination from the bottler which was slight as indicated by colon counts ranging between 2 and 20 per cc on October 3, 15 and 16, was due to a mixture of condensation water and pasteurized milk which sometimes dripped into the bottler bowl from a loose coupling in the sanitary line. This coupling contained arms several inches in length to make it possible for the men working at the bottle-filler to adjust by hand the height of the float valve when changing the size of bottles. The milk which leaked from the coupling dripped from the ends of the arms. Two covers were provided for the bottler bowl but were sometimes removed and offered only partial protection against leakage when used. Three samples of the mixture of milk and water which dripped from this coupling yielded colon counts of 2,600; 5,000 and 1,280 per cc respectively.

While recontamination from this source was not great as possibly only one or two drops of the mixture entered a bottle of milk, it was potentially dangerous due to the possibility of contamination with pathogens from human sources. The danger of this sort of recontamination, though slight, must be recognized since records obtained from the United States Public Health Service (3) show that 3 out of 11 disease outbreaks occurring in pasteurized supplies during the past 5 years were typhoid fever outbreaks that were traced to typhoid carriers who operated either bottling machines or handled bottles.

The sources of recontamination with colon organisms and their significance were called to the attention of the plant manager. On October 16, a meeting was held with plant employees at which instructions were given in regard to the care and sterilization of equipment. Subsequently, all sani-

tary fittings and piping were boiled daily for 10 minutes and remaining equipment thoroughly sterilized. A new single piece cover was provided for the bottler which adequately protected against recontamination from the source previously discussed. As an additional safeguard, a chlorine solution was provided for sterilization of hands of employees working on the bottling machine. The operator in charge of the pasteurizer steamed the outlet line thoroughly before the outlet valve was opened.

The effectiveness of these changes is shown by the fact that subsequently (October 17–November 1) colon organisms were recovered in the case of only 2 out of 33 samples and then in only small numbers (1 per cc and 4 per cc). If the present methods are continued, the bottled pasteurized milk from this plant should remain free from colon organisms in 1 cc quantities.

SUMMARY AND CONCLUSIONS

A study of 271 samples of raw and pasteurized milk collected over a one-year period at two pasturizing plants by means of standard agar plate counts and plate counts of colon organisms showed that the pasteurized milk from one plant was frequently recontaminated before it was bottled. While recontamination was usually indicated by both standard agar plate counts and counts of colon organisms, there were instances in which one or the other of the two methods indicated recontamination when the other method did not. Therefore, the test for organisms of the colon group should supplement and not supplant the standard agar plate count.

Sources of recontamination as indicated by counts of colon organisms from 92 special samples were (1) failure to steam milk lines leading from outlet valves of batch pasteurizers (2) improper cleaning and sterilization of the milk pump, and (3) leakage of milk and water from a sanitary connection contaminated by human sources into the bowl of the bottler. The latter source was potentially dangerous.

Properly pasteurized milk free from recontamination did not contain colon organisms in 1 cc quantities.

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(2) Leifson, Einar. Jour. Path. and Bact. 40: 581. 1935. Also personal correspondence, 1934.

(3) U. S. Public Health Service, Office of Milk Investigations. Milk-borne outbreaks reported by state and city health officers as occurring in the United States in 1929–1934. Mimeographed reports E-875, H-875, B-460, B-466a. Also personal correspondence.

American Dairy Science Association Announcements

THIRTY-FIRST ANNUAL MEETING, JUNE 16–19, 1936
STATE COLLEGE, PENNSYLVANIA

HOUSING PLANS

The college dormitories will be available to those attending the meeting at 75¢ a night with two or more people in a room, or $1.00 a night, one person in a room. Extra cots will be provided for children. The rate for children will be the same as for adults. The dormitory buildings are new, and the rooms are large, airy, and well equipped. The Committee on Housing is doing everything possible to make everyone comfortable while here.

If you wish to bring the family, several cottages on the campus will be available. These cottages hold from twelve to fourteen persons and have two or three separate bathrooms. In all dormitories and cottages it will be necessary for you to furnish your own *towels* and *soap*. Tourist cabin accommodations are not available in the vicinity of State College. A large number of very good tourist homes are available, however, in the town of State College which is adjacent the campus.

Members desiring to stop at hotels may make their own reservations at The State College Hotel, corner of College Avenue and Allen Street; rates, $1.50 to $3.00 single and $3.00 to $6.00 double. The Penn State Hotel is also conveniently located at 310 East College Avenue; rates, $1.50 single and $2.50 double.

All reservations and further information on housing should be obtained from the Chairman of the Housing and Registration Committee, Doctor M. A. Farrell, Department of Bacteriology, State College, Pennsylvania.

A golf tournament is being planned for members. Anyone interested should make their wishes known to Professor R. H. Olmstead, Chairman of Committee, for this event, Department of Dairy Extension, State College, Pennnsylvania.

Optional tours starting at 2 P.M. on Friday, June 19, were announced in the April issue of the JOURNAL. Members planning on the trip to the Dairy Bureau Laboratories and the farm at Beltsville, Maryland, at the close of the meetings should get in touch with the Chief of the Bureau of Dairy Industry, Mr. O. E. Reed, Department of Agriculture, Washington, D. C. Members of the Dairy Bureau are planning to entertain Dairy Science visitors at Washington and Beltsville on Saturday morning, June 20, at 9:00 o'clock.

PROGRAM FOR LADIES, YOUNG PEOPLE AND CHILDREN

JUNE 16—TUESDAY

8:30 P.M. Informal social get-together for members and their families, Second Floor Lounge, New "Old Main Building."

JUNE 17—WEDNESDAY

9 A.M.–4 P.M. Mountain tour for ladies, young folks and children of members. Standard buses will provide safety and comfort. See the laurel in bloom in the beautiful Seven Mountains, and visit Alexander Caverns. Luncheon at Greenwood Furnace, one of the real beauty spots. Complimentary tickets covering the whole trip at registration.

JUNE 18—THURSDAY

9 A.M.–12 noon For young folks and children. Supervised play, municipal playground or mountain hike for those who prefer it.

10 A.M.–12 noon For ladies. Rest or see places of interest on campus. Old Main Tower, Home Economics Building, Mineral Industries Exhibits and Rose Gardens adjacent the dairy building. Not an organized tour. Golf for those who prefer it.

2 P.M.–4 P.M. For children and young folks. Swimming at the Glennland Pool, finest in Pennsylvania. Bring your bathing suits along. Mothers included if they so desire. Exclusive use of pool reserved. Complimentary tickets at registration.

2 P.M.–4 P.M. Entertainment for ladies at the Nittany Lion Inn. Favors by courtesy of cooperating commercial organizations.

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ABSTRACTS OF LITERATURE ON MILK AND MILK PRODUCTS

BUTTER

Factors Affecting Economical Manufacture, Uniformity in Composition and Quality of Butter. D. H. Nelson, Dairy Industry Div., Univ. of California, Davis, California. J. Dairy Sci. *18*, 4, p. 207, April, 1935.

Samples of butter, taken from the churn and representing between 60 per cent and 70 per cent of the butter made in California during 1932, were analyzed by the Kohman Method. The majority of these samples contained between 80 per cent and 81 per cent fat, and between 0.60 per cent and 0.70 per cent "curd by difference." These figures do not agree with "averages" given by five recognized references. They do, however, emphasize the importance, in controlling the overrun, of making a complete analysis instead of assuming that the curd content is 1.0 per cent. They also emphasize that even under commercial conditions, a fat content between 80 per cent and 81 per cent can be easily maintained. The resulting high overrun (23.3 per cent to 24 per cent) is important in the economical manufacture of butter. Maintaining the composition within these narrow limits results in a more uniform quality of butter. D.H.N.

The Hydrogen-ion Concentration of Creamery Waters and Their Relationship to Washing Butter. N. S. Golding, Univ. of Idaho, Agr. Exp. Sta., Moscow, Idaho. J. Dairy Sci. *18*, 6, p. 359, June, 1935.

The reaction (pH) of a number of creamery water supplies in Idaho and Washington have been made at their respective creameries by colorimetric methods. As a considerable proportion of these waters were found to be alkaline in reaction, one such supply was employed to determine the effect of an alkaline water, when used for washing butter.

The first wash water, after washing the butter, was found to have a reaction between that of the water and cream while the second wash water retained the reaction of the original water. On determining the reaction of the serum of the butter, only slight changes were found; therefore, it was concluded that the changes in the reaction of the second wash water were largely a surface effect on the butter.

The nitrogen (protein) removed from butter in the grain by wash waters at various reactions was determined and found to be slightly greater in the alkaline wash waters as compared with those which had been acidified. After extraneous buttermilk was removed, which affected the reaction of the first wash water, the evidence of dissolved protein in the alkaline wash water was more marked.

The effect of alkaline water on the texture of the butter by possibly liberating more free fat in the butter was anticipated, but further experiments are necessary to establish the theory. N.S.G.

A Method for the Microscopic Examination of Butter. A. C. Fay, Kansas Agr. Exp. Sta., Manhattan, Kansas. J. Dairy Sci. *18*, 9, p. 603, Sept., 1935.

One-tenth ml. of melted butter, one drop of Mayer's egg-albumin mixture, and one drop of xylol are thoroughly mixed and spread over the entire surface of a 1 × 3-inch glass slide. After heating for 10 to 15 minutes on a hot water bottle at 80° C., the smear is fixed in 70 per cent alcohol, immersed in xylol, air dried, and stained in methylene blue. If the microscopic field is adjusted to a diameter of 0.157 mm., the average number of bacteria per field multiplied by 1,000,000 gives the number per ml. of butter. A.C.F.

The Creatine Test for Acetylmethylcarbinol Plus Diacetyl in Butter Cultures. B. W. Hammer, Iowa State College, Ames, Iowa. J. Dairy Sci. *18*, 9, p. 579, Sept., 1935.

The creatine test for acetylmethylcarbinol plus diacetyl in butter cultures is an adaptation of the O'Meara test for detecting the formation of acetylmethylcarbinol by bacteria fermenting carbohydrate. The test makes it possible to quickly secure general information on the comparative amounts of acetylmethylcarbinol plus diacetyl present in various cultures. B.W.H.

Diacetyl in Cold-stored Butters. D. R. Barnicoat, Res. Inst. (N. Z.) Dept. of Sci. and Ind. Res., Palmerston North, N. Z. J. Dairy Res. *6*, 3, p. 397, Sept., 1935.

In four churnings of the common non-starter butter, acetylmethylcarbinol was found to the extent of 0–0.6 p.p.m. when fresh and a trace to 0.4 p.p.m. after 6½ months of storage at 14–17° F. The addition of 2½–4 per cent of starter to split batches of the same cream as used for the above butter samples increased the acetylmethylcarbinol content of the fresh butter to 0.7–2.0 p.p.m. when fresh and 0.8–1.8 p.p.m. after 6½ months of storage. The diacetyl content was not determined in these butter samples when fresh, but was found to be zero in the non-starter butter after three and six months and 0.4–4 p.p.m. in starter butter after three months and 0–0.2 p.p.m. in the butter after 6½ months of storage at 14–17° F. Thus there appeared to be little change in the natural carbinol plus diacetyl content of butter during storage.

The author concluded that most of the acetylmethylcarbinol plus

diacetyl found in the butter from slightly ripened cream was not developed during the ripening process but was added preformed in the starter. He points out that apparently the final concentration of carbinol plus diacetyl in butter is dependent upon the amount of buttermilk retained and these substances are held in the aqueous portion, possibly adsorbed on the protein, rather than dissolved in the fat.

When diacetyl in the amount of 4 p.p.m. (1 per cent of a 400 p.p.m. solution made from Polak's 50 per cent diacetyl) was added to either "non-starter" or "starter" butter, considerable losses of diacetyl occurred during storage. The extent of the losses of diacetyl is about the same (40 per cent) for the "non-starter" and "starter" butter, but in the "starter" butter, part of the diacetyl has merely been reduced to its precursor (carbinol) form by the action of the lactic streptococci. It is inferred that from the point of view of aroma alone the "starter" butter will maintain a better flavor during storage than "non-starter" butter.

The loss of diacetyl in "non-starter" butter and to a lesser extent in the "starter" butter is considered to be due to oxidation to acetic acid by incorporated air. H.A.B.

Preparing Butter Samples for Analysis. D. H. Nelson, Univ. of California, Davis, California. J. Dairy Sci. *18*, 10, p. 667, Oct., 1935.

A modification of the horizontal spiral bit type of mechanical mixer is described for preparing samples of butter for analysis. This modification has been designed to overcome the more serious disadvantages of mechanical mixers used for this purpose. The following conclusions are drawn from the data presented: (1) Any temperature between 12° C. and 24° C. may be used, (2) partial separation of the sample, caused by melting around the edges, seriously interferes with the proper preparation of the sample, and (3) the sample must be mixed for at least 3 full minutes.

D.H.N.

Factors Affecting Milk and Butterfat Secretion. I. Variations in Fat Weight, Fat Percentage, and the Amount of Fat in the Milk Required to Make a Given Weight of Butter. Elizabeth O. Whetham and John Hammond, School of Agriculture, Cambridge, England. J. Dairy Res. *6*, 3, p. 320, Sept., 1935.

Dairy show records were examined for the ratio of the weight of fat in the milk required to make a pound of butter. This ratio was taken to indicate the size of the fat globule in the milk. From such considerations the authors believe to have found support for the theory that the size of the fat globule is in some degree conditioned by the rate of milk secretion, an increased rate resulting in smaller globules. The size of the globules is

smaller because they are washed out from the cell at a greater rate of speed. Furthermore the size of the fat globule is held to be influenced by the rate of butterfat formation by the cell, which varies with breed and stage of lactation. H.A.B.

Committee Comments: The method used by the authors for churning and calculating the fat weight: butter weight ratios is not clear. All ratios of fat weight: butter weight given are greater than 1 and the authors state, "It requires, at the one extreme with Friesian milk, 1.260 lb. of fat to make 1 lb. of butter, and at the other extreme with Jersey milk 1.011 lb. of fat to make 1 lb. of butter." How the fat weight: butter weight ratios can be higher than one is not clear as the weight of butter should exceed the weight of fat.

Factors Affecting Milk and Butterfat Secretion. II. The Colour of the Butterfat. ELIZABETH O. WHETHAM AND JOHN HAMMOND, School of Agriculture, Cambridge, England. J. Dairy Res. *6*, 3, p. 340, Sept., 1935.

The colors of the butter for individual cows at the London Dairy Show were measured on a color scale made by spraying the colors on celluloid strips and coating them with cellulose. The mean values and variability curves of the ranges of butter color in the different breeds of dairy cattle are given. The breeds studied ranked as follows in the intensity of the butter color: South Devon, Guernsey, Jersey, North Devon, Friesian, Shorthorn, Ayrshire, Dexter, Red Poll, Kerry. From 25 to 263 cows in each of these breeds were studied and the feeds of the cows were not the same.

A slight increase in the shade of color was found to occur under most of the various conditions which give rise to increased milk yield, which may be due to the greater amount of coloring matter in proportion to butterfat produced. Milking three times a day caused a slightly darker yellow butter than twice daily milking, especially in the case of Shorthorns and Ayrshires. The difference was not significant for Friesians and Jerseys.

Age had little influence on the butter color although the tendency seemed to be toward a slightly darker color as age increases. The advance of the lactation period also showed no very distinct effect on the butter color within the individual breeds in this study, although the average of all breeds indicated a slight drop in color intensity during the first 120 days of the lactation period when more fat is required from the body in addition to that from the food. After 150 days the color gradually rises again as the butter yield falls and more of the fat is supplied by the food intake. It is suggested that butterfat derived from body fat will be paler than that from food fat, when the latter is sufficiently provided with plant pigments, because when fat is withdrawn from the body cells, the pigment is partially retained and becomes concentrated in them. H.A.B.

Sanitary Conditions in Creameries Improved, Says Food Official. J. O. CLARKE, Food and Drug Administration, U. S. Dept. of Agriculture. Dairy Produce *41*, 10, p. 9, October, 1935.

This is a summary of the work of the Food and Drug Administration of the United States Department of Agriculture in the cream quality improvement campaign. Data are given showing the number of cans of cream and pounds of butter examined and the percentage of condemnation. In the summer and fall of 1934, 3.51 per cent of all cream examined was condemned. In the period from January to July, 1935, 4.35 per cent was condemned, while in the period from July to September, 1935, only 2.70 per cent was condemned. Of the cream condemned 41.8 per cent was condemned as cheesy, 23.1 per cent as moldy, 20.8 per cent as putrid, 8.2 per cent as yeasty, 3.4 per cent as rancid, and 2.7 per cent because of extraneous matters. S.T.C.

The Effect of Soybeans in the Rations of Dairy Cows upon the Vitamin A Value of Butter. J. W. WILBUR, J. H. HILTON, AND S. M. HAUGE, Dept. Dairy Husb., Purdue University, Lafayette, Indiana. J. Dairy Sci. *18*, 10, p. 661, Oct., 1935.

Soybeans in the rations of dairy cows suppress the transference of the vitamin A activity of the ration to the butterfat. Dairy cows which received constant levels of vitamin A throughout the successive periods, produced butter of lower vitamin A value when soybeans were fed in the grain ration than when linseed oil meal was used. The attempt to correct this suppressing action by roasting the soybeans used in the grain ration was unsuccessful. J.W.W.

CHEESE

The Bacteriology of Swiss Cheese. II. Bacteriology of Swiss Cheese in the Press. W. C. FRAZIER, L. A. BURKE, A. J. BOYER, AND G. P. SANDERS, U. S. Dept. of Agric., Washington, D. C. J. Dairy Sci. *18*, 6, p. 373, June, 1935.

Bacterial activity in Swiss cheese from the time the curd is dipped from the kettle until 21 hours later was controlled largely by the temperature of the cheese. The temperature at dipping (50.0–51.0° C.) prevents the increase in numbers of bacteria for several hours although the pH was found to decrease rapidly. This increase in acid without apparent growth of bacteria was explained by the fact that the cells were many times larger in volume and therefore capable of comparatively greater activity per cell; moreover, small amounts of acid produce relatively large changes in pH due to the relatively low buffer value of the cheese mass when the pH is high. *Streptococcus thermophilus* (C_2) increased in numbers within

3 or 4 hours after dipping, grew rapidly until the 6th or 8th hour, and was chiefly responsible for the production of acid during this 6-hour period. The lactobacilli organisms did not start growth until the cheese had cooled below 44° C. *Lactobacillus bulgaricus* (Ga) showed growth after the 5th hour and *Lactobacillus helveticus* (39a) not until after the 10th hour. Bacterial activity and acid production from the 8th to 21st hour was attributed largely to the lactobacilli. *S. lactis* died off rapidly in the press. *Escherichia communior* and *Aerobacter aerogenes* grow in the press and may cause gassiness or "bloat"; active starters of *S. thermophilus* and lactobacilli effectively inhibit them. The presence of large numbers of *A. aerogenes*, even though inactive in the press, resulted in poor quality cheese. *Propionibacterium shermanii* do not grow but usually decrease in numbers in the press. *L. lactis* and *L. longus* types were able to grow rapidly, but usually were not present in large numbers. These studies were with cheese of 55 pound weight but comparisons were made with factory cheese. The lactobacilli start growth several hours later in factory cheese due to the slower cooling in the larger cheese. Bacterial determinations were made by microscopic counts supplemented by a special staining technique showing living cells. L.A.B.

The Bacteriology of Swiss Cheese. III. The Relation of Acidity of Starters and of pH of the Interior of Swiss Cheeses to Quality of Cheeses. W. C. Frazier, W. T. Johnson, Jr., F. R. Evans, and G. A. Ramsdell, Res. Laboratories, Bureau of Dairy Ind., Washington, D. C., and Grove City, Pa. J. Dairy Sci. *18*, 8, p. 503, Aug., 1935.

A study of Swiss cheese manufactured under factory conditions has indicated that a good quality of cheese is likely to result when a *Lactobacillus helveticus* milk starter with an acidity of 1.0 to 1.09 per cent after growth for 12 hours at 37.5–39° C. is used together with a 12-hour, 37° C. milk starter of *Streptococcus thermophilus* with a titratable acidity of 0.7 to 0.75 per cent or a whey starter with an acidity of 0.30 to 0.33 per cent. The pH of the interior of the cheese in the press, which is indicative of the activity of the starter organisms, should be about 6.0 to 6.09 after three hours in cheese made from milk with a pH of 6.5 to 6.6 and should be less than 5.2 after 21 hours in the press; preferably the pH should be between 5.15 and 5.0. W.C.F.

The Preparation of Mold Powder for Blue-veined Cheeses. R. V. Hussong and B. W. Hammer, Iowa State College, Ames, Iowa. J. Dairy Sci. *18*, 9, p. 599, Sept., 1935.

The method consists of growing the desired mold on bread under aseptic conditions, drying, and grinding to a fine powder. The advantages of

the method are (a) high yield of powder containing a large number of mold spores per gram, (b) relatively short time required for the preparation of the powder and (c) freedom of the powder from contaminating molds. R.V.H.

The Function of Pepsin and Rennet in the Ripening of Cheddar Cheese. I. R. SHERWOOD, Dairy Res. Inst. (N. Z.), Palmerston North, New Zealand. J. Dairy Res. *6*, 3, p. 307, Sept., 1935.

The purpose of this investigation was to obtain confirmatory evidence for the contention developed in a previous work that the breakdown of cheese protein during ripening of the cheese is due almost entirely to the proteolytic enzymes of the rennet retained in the cheese.

In a preliminary experiment, raw skimmilk to which 2 per cent chloroform had been added was used as a substrate and it was found that an increased concentration of rennet as well as pepsin leads to a more complete protein breakdown in the milk. A 6.25 per cent solution of pepsin, however, had only about $\frac{1}{3}$ as great proteolytic power as the rennet solution used.

In the first regular experiment cheese was made from milk flash heated to 155° F. and coagulated with rennet, with pepsin and rennet, and pepsin and the type and extent of protein breakdown during the ripening of the cheese was observed. The pH values of the resulting cheeses in the green state were nearly the same and there were no marked differences in the bacterial counts of the cheese during the ripening period. The extent of the protein breakdown in the cheeses made with pepsin was much smaller than that made with the rennet, and when a mixture of pepsin and rennet was used the extent of the protein breakdown was intermediate.

In another experiment the doubling of the amount of rennet used from four ounces per 1000 pounds of milk to eight ounces caused a considerable increase in the degree of protein decomposition. The type of nitrogen breakdown was similar in all batches in both experiments.

A "pepsin" solution prepared by heating rennet to 70° C. for two minutes at a pH of 5 in order to destroy the rennin exhibited a coagulating power which was only $\frac{1}{2}$ to $\frac{1}{8}$ that of the unheated rennet. When 5 per cent solutions of commercial pepsin were heated in this manner, their coagulating power was only 5 per cent of the original.

A "rennin" solution prepared by heating rennet to 38° C. for 10 minutes at a pH of 7.25 to destroy the pepsin had a clotting power which was not markedly reduced although at times it was reduced to $\frac{1}{2}$. When prepared in the same manner, from 5 per cent solutions of commercial pepsin, its clotting power was only 1/50 that of the original pepsin solution.

The above heat treatments on either rennet or commercial pepsin solu-

tions had only very little influence upon the proteolytic activity of the coagulations. It is concluded that the heat treatments mentioned are not effective in destroying rennin and pepsin and that the proteolytic activity and coagulating action are due to separate enzymes. It is also suggested that a rough guide to the comparative protein breakdown that will occur in cheese is given by measurement of the degradation brought about in milk by the respective coagulating enzymes employed. H.A.B.

CONCENTRATED AND DRY MILKS

The Heat Stability of Evaporated Milk Made from Hard-curd Milk, Soft-curd Milk and Milk from Mastitis Infected Udders. R. C. WELCH AND F. J. DOAN, Div. of Dairy Manuf., The Penn. State College, State College, Pa. J. Dairy Sci. *18*, 5, p. 287, May, 1935.

There is apparently no difference in the stability toward heat between hard-curd milk and soft-curd milk after condensation under uniform conditions. Concentrated milk from animals afflicted with subclinical mastitis in one or more quarters of the udder, however, is decidedly less stable than normal milk. It furthermore reacts oppositely toward factors affecting stability, being stabilized by agents which destabilize normal milk and vice versa. This is probably a reflection of the altered mineral composition of mastitis milk. F.G.D.

ICE CREAM

The Storage of Packed Ice Cream. RICHARD W. SMITH, JR., Dairy Dept., Vt. Agr. Exp. Sta., Burlington. Vt. Agr. Exp. Sta. Bul. 394, June, 1935.

The storage of packaged ice cream was studied with respect to its effect upon flavors, shrinkage and surface condition.

The batches of vanilla, chocolate, strawberry and maple walnut ice creams were made, five in the University dairy laboratory and five in a commercial plant.

In general, 13 quarts and 13 pints of each flavor were withdrawn from storage the day after each batch was frozen, marked, carefully weighed and replaced in storage. A pint and quart package of each flavor was withdrawn weekly for about seven weeks and thereafter fortnightly until supply was exhausted. At these times they were reweighed and critically examined for flavor, texture and body. It was concluded that:

Vanilla, strawberry, chocolate and maple walnut ice creams stored at hardening room temperatures of from –6° F. to –20° F. do not materially change in weight over periods of from 16 to 24 weeks, nor do they shrink appreciably in volume.

Unlined packages of vanilla and strawberry ice creams developed sur-

face film in from 107 to 114 days, maple ice cream sometimes filmed slightly in about the same time, whereas chocolate goods developed no film. No film formed in lined packages.

In general, the body and texture of packaged ice cream did not deteriorate with age. Chocolate and maple walnut ice creams kept well and retained their desirable flavors over periods of three to four months. Vanilla may develop "off-flavors" in about 100 days. Strawberry is more likely to develop flavor trouble during storage than the other three and should be held for not more than two and preferably not more than one month.

It was pointed out that manufacturers may avoid excessive peak loads by storing chocolate and maple walnut ice creams, and possibly small amounts of vanilla, several weeks ahead of the rush period, thus freeing equipment for use in making ice creams and sherbets that do not keep as well. It was also pointed out that the initial quality of the ice cream must be good or successful storage is impossible. J.M.F.

Committee Comments: It is well known that the quality of the ingredients used in ice cream affects its keeping quality and that ice cream never improves with age. Hence, the period of time between manufacture and consumption should be as short as possible.

A Study of Factors Influencing the Separation of Whey in Ice Cream Mixes Containing Vegetable Stabilizers. I. A. GOULD AND P. S. LUCAS, Michigan State College, East Lansing, Michigan. J. Dairy Sci. *18*, 5, p. 307, May, 1935.

Ice cream mixes containing 0.4 per cent of a gum containing stabilizer known to cause whey separation were subjected to various temperature treatments. Pasteurization of the mixes before and after adding the stabilizer demonstrated that the agent causing the difficulty is heat labile and is principally found in, or due to, the milk products of the mix rather than the stabilizer. Pasteurization of the milk products of the mix at 145° F., 165° F., and 175° F. for 30 minutes before adding the stabilizer gave an average whey separation after 96 hours of 41 per cent, 22 per cent, and 10 per cent respectively. Heating the milk products to 205° F. for 1 hour practically eliminated the difficulty, while the heating of a solution of the stabilizer to the same temperature for 2 hours brought a reduction in the whey separation of approximately only 50 per cent. Excessive drying of the stabilizer or variations in the fat and serum solids of the mix had little or no influence on the separation of the whey. P.S.L.

Some Physical Effects of Freezing upon Milk and Cream. B. H. WEBB AND S. A. HALL, Bureau of Dairy Industry, U. S. Dept. of Agr., Washington, D. C. J. Dairy Sci. *18*, 5, p. 275, May, 1935.

Slow freezing of milk or cream caused a gradual precipitation of the caseinate system and an immediate destruction of the fat emulsion. Freez-

ing did not alter the heat stability of skim milk until the product had been held frozen for several months at –18° C. (0° F.) or below. Freezing caused an immediate increase in the amount of casein which could be centrifuged from milks heated before freezing. Freezing, therefore, caused a slow and gradual increase in the size of the casein aggregates but the change was not noticeable until the freezing period was well advanced. The destruction of the fat emulsion in cream during slow freezing was lessened by adding cane sugar or increasing the solids-not-fat content of the cream before freezing. Homogenization slightly retarded fat separation when low fat creams were frozen. Freezing destroyed the fat clumps formed in cream by homogenization and restored to the cream the heat stability which it possessed before processing. Fresh whole milk was pasteurized, condensed to ⅓ its weight, canned and frozen without any detrimental effects to the body or flavor of the product. This milk when held frozen at a low temperature and reconstituted at any time within a four-week period by the addition of cold water, yielded a product which often could not be distinguished from fresh market milk. Its use where fresh market milk is expensive or not available was suggested. A process for the preparation of large quantities of normal undenatured casein and of milk serum was developed. Frozen homogenized cream was thawed at a temperature below the melting point of the fat; clear milk serum was collected from the melting mass and the residual mixture of fat and casein was utilized in the preparation of normal casein or to raise the protein solids of ice cream mix. B.H.W.

Observations on the Freezing of Milk and Cream. F. B. Baldwin, Jr., and F. J. Doan, Penn. Agr. Exp. Station, State College, Pa. J. Dairy Sci. *18*, 10, p. 629, Oct., 1935.

The variations in the percentage of fat in the frozen and unfrozen portions of milk, partially frozen without agitation, were found to be due to the creaming phenomenon.

Cream containing over 25 per cent of fat was found to freeze homogeneously, the frozen and unfrozen portions having the same concentration of colloidal and soluble substance throughout the entire range of freezing to apparent solidity.

It was concluded that increasing amounts of fat interfered physically with the diffusion and concentration of the constituents into the unfrozen portions of unagitated, freezing cream. F.B.B.

MILK

Oxidized Flavor in Milk. I. The Probable Relation of Lecithin to Oxidized Flavor. L. M. Thurston, W. Carson Brown, and R. B. Dust-

MAN, West Va. Agr. Exp. Sta., Morgantown, West Va. J. Dairy Sci. *18*, 5, p. 301, May, 1935.

Butterfat from milk of oxidized flavor, when washed free of substances adsorbed on the fat globules and redispersed in skimmilk of good flavor, gave no trace of oxidized flavor to the resulting reconstituted milk. Subjection of the reconstituted milk to the treatment by which oxidized flavor had been developed in the normal whole milk failed to cause the development of oxidized flavor in the reconstituted milk. That oxidized flavor in milk differs from the flavor caused by oxidized butterfat was indicated when purified oxidized butterfat redispersed in skimmilk of good flavor yielded a tallowy flavor which was distinctly different from the so-called oxidized flavor. These results indicate that oxidized flavor in milk develops first in some substance adsorbed on the fat globules and the authors offer evidence that this substance probably is lecithin. L.M.T.

Flavors of Milk and Their Control. C. L. ROADHOUSE AND J. L. HENDERSON, Univ. Farm, Davis, Calif. Univ. of Calif. Bull. 595, 1935.

For several years flavor studies have been continued by the authors and in this publication the available information is well summarized. The authors adhere to the usual distinction between taste and flavor; namely that taste is the impression perceived when the milk is taken into the mouth while flavor is a combination of taste and smell observed when the milk is in the mouth.

In studying the variations in the taste of milk produced by different cows, the feed was withheld for 5 hours before milking. This study shows that a low chloride-lactose number (per cent chloride/per cent lactose $\times$ 100) is usually associated with a desirable primary taste, also that 12.68 per cent of the 536 cows in 12 herds produced milk having abnormal taste or flavor.

The study of feed flavors was divided in two parts: (1) those due to roughage, and (2) those due to concentrates. Musty hay, corn silage, green barley, green wild oats, green foxtail, green filaree, alfalfa hay, green alfalfa, clover hay, and clover pasture impart a feed flavor the intensity of which increases both as the amount of feed consumed increases and as the interval of time between feeding and milking becomes shorter. Even 5 pounds of alfalfa hay, 10 pounds of green alfalfa, or 10 pounds of corn silage produced a distinct and undesirable flavor when fed one or two hours before milking. Tame oat hay when fed two hours before milking imparts a "slight after-flavor" if 8 or 9 pounds are consumed but has no detrimental effect when only 5 pounds are fed. Feeding tame oat hay together with any roughage which does impart a feed flavor to the milk does not modify the intensity of the flavor. When natural green feed is fed, the flavor is most prominent in milk drawn approximately one or two hours

afterward. In no case did the milk with feed flavors score below 20 points for flavor.

The usual concentrate feeds—rolled barley, cocoanut meal, soybean meal, cottonseed meal, wheat bran, and dried beet pulp—when fed one to two hours before milking, in quantities used by the average commercial dairyman, did not give milk sufficient flavor to make it undesirable to the average consumer. Wheat bran seemed to improve the flavor of the milk when fed in 5½ to 7-pound quantities one hour before milking.

Three abnormal conditions of the cow were reported that affect the taste and flavor of the milk. Salty taste was observed in milk from certain cows which were advanced in lactation and also from one or more quarters of udders previously affected with mastitis. Saltiness resulting from mastitis is more easily detected from the physical condition of the udder and usually also from the appearance of the milk itself. Usually one cannot recognize salty taste in mixed milk produced by several cows because of the dilution of abnormal with normal milk. Rancid milk was produced by certain cows which had been milking longer than the usual lactation period. Occasionally such milk appears in the first months of lactation. The cause of rancidity that quickly develops in certain milks is the enzyme lipase present in them at the time they are drawn from the cow, but the conditions controlling the presence of lipase in the milk are not known. Pasteurization of milk within a few hours after milking will destroy the activity of the lipase and prevent the development of rancidity.

Oxidized flavor develops in milk that has been in contact with certain corrodable metals. Copper and its alloys have been found to be the most common cause of oxidized flavors. Exposure to sunlight also causes an oxidized or tallowy flavor. The use of non-corrodable metals and the protection of milk from strong sunlight during processing and delivery will eliminate the cause of these defects. D.H.N.

The Germicidal Efficiency of Lye and Chlorine Solutions for the Sterilization of Milking Machines and Cream Separators. A. C. Fay, W. J. Caulfield, and W. H. Riddell, Kansas Agr. Exp. Station, Manhattan, Kansas. J. Dairy Sci. *18*, 4, p. 239, April, 1935.

Milking machine tubing and teat cups may be effectively sterilized either with chlorine solutions testing 100 parts per million available chlorine or with 0.3 lye solutions, if the solution rack method is used. When the milking machine parts are immersed in crocks containing these solutions, the chlorine disinfectants are less satisfactory.

Chlorine solutions proved to be more effective than lye when used as a disinfectant rinse for cream separators. The results indicate that chlorine solutions used for this purpose should contain at least 200 parts per million

available chlorine in order to insure effective sterilization. Little difference was noted in the germicidal efficiencies of lye solutions containing 1.00, 0.75, and 0.50 per cent sodium hydroxide. Since exposure of separator discs to a 0.5 per cent lye solution tends eventually to corrode the surfaces, the use of lye for sterilizing cream separators is not recommended.

A.C.F.

The Detection of Formaldehyde in Milk by Means of the Methylene Blue Reduction Test. A. C. Fay, Kansas Agr. Exp. Sta., Manhattan, Kansas. J. Dairy Sci. *18*, 5, p. 327, May, 1935.

It is possible to use the methylene blue reduction test as a basis for suspecting the presence of formaldehyde in milk. The addition of effective quantities of formaldehyde shortens the reduction time, especially if the methylene blue reduction test is run soon after the formaldehyde has been added. Specifically any sample of fresh milk which shows a reduction time of less than one hour may be suspected of containing formaldehyde, and should be subjected to more exact qualitative test.

The range of dilutions of formaldehyde which effectively retarded bacterial growth, definitely delayed coagulation time, and at the same time escaped detection by a majority of those who tasted the milk was between 1:15,000, and 1:25,000. This narrow zone suggests that the addition of formaldehyde to milk by the dairyman is more likely to fail than to accomplish the results desired. A.C.F.

The Effect of Mastitis upon Milk Production. A. O. Shaw and A. L. Beam, Dairy Dept., The Penn. State College, State College, Pa. J. Dairy Sci. *18*, 6, p. 353, June, 1935.

Mastitis infection was found to reduce milk production approximately 22 per cent and butterfat production approximately 24 per cent after allowance was made for the maximum variation found in the milk and butterfat production of non-infected quarters. A.O.S.

Biological Methods for the Analysis of Dairy Products. P. A. Downs, B. W. Hammer, W. A. Cordes, and H. Macy. J. Dairy Sci. *18*, 10, p. 647, Oct., 1935.

Methods are given for the bacteriological analysis of condensed and evaporated milk. Tests for sterility and the determination of anaerobic, thermophilic, and spore-forming bacteria in evaporated milk, hemolytic streptococci, thermophilic, and gas-forming bacteria causing thickening and gas-forming yeasts, and the yeast and mold content of condensed milk are outlined. Special media for some of these purposes are described. H.M.

A Comparison of Methods of Detecting Streptococci in Freshly Drawn Milk Samples. WAYNE E. PLASTRIDGE, E. O. ANDERSON, AND FRANCIS J. WEIRETHER, Storrs Agr. Exp. Sta., Storrs, Connecticut. J. Dairy Sci. *18*, 9, p. 583, Sept., 1935.

The relative efficiency of six methods used for the detection of the causative organism of chronic streptococcal bovine mastitis, was determined on 360 individual quarter milk samples. Seventy-nine or 21.9 per cent of the milk samples showed laboratory evidence of mastitis and the presence of streptococci by one or more tests. The incidence of positive findings given by the six methods varied from 3.8 to 98.7 per cent. Microscopic examination of films prepared from incubated milk revealed the presence of the causative organism in a larger number of instances than (1) direct microscopic examination of films prepared from whole milk or sediment, and (2) blood agar plates inoculated with a 4 mm. loopful of whole mlik, or a 4 mm. loopful of sediment, or 1 cc. of a 1 to 10 dilution of the sample.

E.O.A.

The Advantages of Skim-milk Agar for the Determination of the Sanitary Quality of Market Milk. C. E. SAFFORD AND C. N. STARK. J. Dairy Sci. *18*, 8, p. 539, Aug., 1936.

The fermentable carbohydrates and other milk constituents in skim-milk agar make it a desirable medium to use in the routine control of market milk and other dairy products.

The skim-milk agar counts on 618 samples of pasteurized milk were, on the average, two to four times as large as the corresponding counts on standard agar. The counts on 137 samples of raw milk were only slightly higher. The colonies were much larger and consequently could be counted with greater ease and rapidity. The slight opacity of the medium prevents the glare often experienced when artificial lighting devices are used. Acid-producing and protein-digesting types of bacteria can be differentiated on this medium. It supports the growth of bacteria responsible for mastitis in cows. It is simple and easy to make and no more expensive than the present standard agar.

G.E.S.

An Unnoted Hemolytic Streptococcus Associated with Milk Products. J. M. SHERMAN AND H. N. WING, Cornell University, Ithaca, N. Y. J. Dairy Sci. *18*, 10, p. 657, Oct., 1935.

A hemolytic streptococcus which is believed to represent a new species is described. This organism differs from the pathogenic species of hemolytic streptococci in its higher maximum temperature of growth, a lower minimum temperature of growth, a higher thermal death point, and a more

acid limiting pH of growth. It also differs from the human types in the hydrolysis of sodium hippurate and its failure to ferment sucrose.

Streptococcus hemothermophilus (n. sp.) is suggested as a name.

G.M.S.

The Types of Coliform Bacteria in Bovine Faeces. J. F. MALCOLM, Bact. Dept., the West of Scotland Agric. College, Glasgow. J. Dairy Res. *6*, 3, p. 383, Sept., 1935.

In an examination of the coliform flora of 114 specimens of faeces from cows confined to byres during the winter and from cows on pasture, a total of 342 cultures of coliform bacteria were isolated by the ordinary methods. Of these, 96.4 per cent, or 330, cultures were typical *B. coli* and only 3.5 per cent, or 12, cultures were of *Bact. aerogenes, Bact. cloacae* and other Koser-positive types. Of the 330 *B. coli* cultures, 211 were obtained from the winter faeces and 119 from the summer faeces. All 12 of aerogenes-cloacae types were found in the winter faeces and none in the summer faeces.

When 100 further specimens were studied by using various enrichment methods, 253 cultures of *Bact. aerogenes, Bact. cloacae* and other Koser-positive types of coliform bacteria were isolated from 95 of the specimens. Of the 253 cultures, 125 came from winter faeces and 128 from summer faeces.

It was concluded that although aerogenes-cloacae types may be the most prevalent coliform organisms in soil, on fodder, and on grains, they are also normal inhabitants of the intestines.

A classification of the coliform group of organisms based on the inositol, Koser nitrate, indole, and Voges-Proskauer reactions is suggested.

H.A.B.

Biennial Reviews of the Progress of Dairy Science. Section B. Bacteriology and Mycology Applied to Dairying. A. T. R. MATTICK, E. R. HISCOX, J. G. DAVIS, National Inst. for Res. in Dairying, Univ. of Reading, England. J. Dairy Res, *6*, 3, p. 422, Sept., 1935.

This bacteriological review covers technique, sanitary milk production, pasteurization, bacteria, cheese, and butter. H.A.B.

Mastitis Streptococci in Bulk Milk. E. J. PULLINGER, Res. Inst. in Animal Pathology, Royal Veterinary College, London. J. Dairy Res. *6*, 3, p. 369, Sept., 1935.

The main object of this investigation was to see whether it is possible to set up a standard for the amount of contamination of raw milk with the streptococci ordinarily causing bovine mastitis which might be reasonably

permitted by pasteurizing plants from the standpoint of the effect of such contamination on the chemical composition of the milk. It was found that such a standard could not be provided because the number of beta-haemolytic streptococci in milk excreted from day to day by individual cows varied too much. The extent of mastitis in a herd may only be estimated by cultural examination of representative samples four to five times at weekly intervals. The counts for beta-haemolytic streptococci per milliliter were five to ten times higher in the gravity cream than in the whole milk. Microscopical examination of gravity cream or of centrifuge deposit for streptococci or leucocytes may give information not obtainable by cultural methods but does not serve as a substitute for cultural examination.

The extent of contamination of graded and non-graded milk with mastitis streptococci confirms a high incidence of chronic streptococcus mastitis. The ideal to be aimed at is the complete eradication of mastitis by suitable control measures and that such a state can be achieved was demonstrated by the persistent freedom from haemolytic streptococci of the milk of two herds. H.A.B.

The Pen Barn and Separate Milking Room. H. F. McColly and J. R. Dice, N. D. Agric. College, Fargo, N. D. N. D. Agr. Exp. Sta. Bul. 283, Nov., 1935.

This is a bulletin dealing with the adaptability of the pen type dairy barn and separate milking room for the dairy farm, the relative construction and labor cost and practicability as compared to the standard type barn. Plans of construction of various types of pen barns are illustrated and discussed in detail. C.J.

Experiments with the Methylene Blue Reduction Test for the Grading of Sweet Cream. H. Macy, Div. of Dairy Husb., Minn. Agr. Exp. Sta., St. Paul, Minn. Minn. Agr. Exp. Sta. Bul. 310, October, 1934.

Methods for making the test and results secured in the use of the methylene blue reduction test for the grading of sweet cream are described. The procedure suggested is similar to that recommended for milk in the Standard Methods of Milk Analysis except that a triple strength methylene blue solution is used. Data are given on the reduction time, percentage of butterfat and acidity, direct microscopic count, standard plate counts at 37° C. (98.6° F.) and two days' incubation, and plate counts at 20° C. (68° F.) and five days' incubation for 159 samples of cream. Observations on the use of the test under practical conditions in three creameries are given. A limited number of data are presented comparing the keeping quality of butter made from better quality sweet cream and that from inferior cream.

The author concludes that the methylene blue reduction time is a satisfactory index of the bacterial content of sweet cream and expedient for use in creameries for the grading of cream. The time required for the reduction of methylene blue was inversely proportional to the bacterial content of the cream. The reduction time of samples of cream showing less than 0.21 per cent acidity showed no direct relationship to the acidity of the cream. The reduction time was not significantly influenced by the percentage of fat in the cream. Butter, unsalted and salted, made from the better quality of cream possessed somewhat better keeping quality than the butter from inferior cream.

The test is recommended as a convenient aid in a program directed toward the improvement in quality of sweet cream. S.T.C.

Effect of Heating Milk on the Time which the Curds Remain in the Abomasum of Calves. F. M. MORTENSEN, D. L. ESPE, AND C. Y. CANNON, Iowa State College, Ames, Iowa. J. Dairy Sci. *18*, 4, p. 229, April, 1935.

Measurements were made on the rate at which the coagula of differently treated milks disappeared from the abomasum of a young calf when the milk was introduced directly into the abomasum by means of a tube through a gastric fistula.

Two liters of raw skimmilk left the abomasum in 12 to 18 hours. The evacuation time of the same quantity of boiled milk was usually 8 to 12 hours. Milk autoclaved at 242° F. passed through the stomach at about the same rate as boiled milk. Raw milk coagulates in the stomach of the calf in from 1 to 10 minutes; boiled and autoclaved milk require 8 to 15 minutes. Measurements of the total acid, free acid and hydrogen-ion concentration of the gastric contents indicate that the acidity of the gastric juice does not vary materially when raw or heated milk is fed. Heated milk leaves the stomach more rapidly than raw milk because heat lowers the curd tension and thus permits the curd to break up more easily.

F.N.M.

Relation of the Proteolytic Enzyme Activity of the Proteolytic Organisms Found in Separator Slime. GEORGE SPITZER AND E. H. PARFITT, Purdue Univ. Agr. Exp. Sta., Lafayette, Indiana. J. Dairy Sci. *18*, 4, p. 267, April, 1935.

A close relation was found between slime and the numbers of proteolytic bacteria contained in the slime. Temperatures usually used in the pasteurization of dairy products (145° F. for 30 minutes and 160° F. for 10 minutes) destroyed approximately 70 per cent of the enzyme action. The experiment was carried out for 14 consecutive months. E.H.P.

Seasonal Variations in the Lipase Content of Milk. J. L. HILEMAN AND ELEANOR COURTNEY, Dairymen's League Co-op. Assoc., Inc., Syracuse, N. Y. J. Dairy Sci. *18*, 4, p. 247, April, 1935.

The relative amount of lipase present in raw milk was determined by concentrating the fat into a small volume of cream (40 per cent fat) by centrifugal separation, holding this cream under conditions which would allow the lipase to act on the fat while inhibiting the growth of bacteria, and following lipolytic activity by titration of the liberated fatty acids with standard alkali. There is some lipase present in raw milk throughout the year, but the amount varies greatly, the minimum occurring in early summer (June or July) and the maximum in early winter (December or January). The increase in amount of lipase is associated with the late lactation. In commercial pratice lipase may produce high titratable acidity and rancid flavor in raw cream during storage at 35 to 40° F. J.L.H.

The Determination of Curd Tension by the Use of Hydrochloric Acid-pepsin Coagulant. DAVID MILLER, Bureau of Animal Industry, U. S. Dept. of Agr., Washington, D. C. J. Dairy Sci. *18*, 4, p. 259, April, 1935.

Evidence is presented that a coagulant of hydrochloric acid and pepsin produces a truer picture of the curd characters of milk and simulating gastric condition than the calcium chloride-pepsin coagulant as used by Hill. The proposed coagulant contains 0.45 grams of pepsin per 100 cc. of 0.4 per cent hydrochloric acid. Holstein, Jersey and Goat milks when given various treatments such as boiling, skimming and homogenizing, showed more uniform changes in curd tension by the hydrochloric acid coagulant than by the calcium chloride. When the milks were boiled for one minute, the curd tension values showed a drop by both methods. The acid coagulant showed a much greater drop in the case of the Holstein and Jersey milks. The values obtained were within or near the limits of soft curd milk. D.M.

Preliminary Observations on Certain Seasonal Variations in the Physical Properties and Nutritive Value of Cow's Milk Serum. F. E. STIRN, C. A. ELVEHJEM, AND E. B. HART, Dept. of Agric. Chem., Univ. of Wisconsin, Madison, Wisconsin. J. Dairy Sci. *18*, 5, p. 333, May, 1935.

The serum of winter produced milk showed physical characteristics at variance with those of summer produced milk. It was clarified with greater difficulty. An adjustment of the salt balance and pH improved somewhat the technique used for the preparation of the serum from winter milk. The time at which these changes occur varies from year to year.

The serum of winter produced milk showed lower nutritive value than

that of summer produced milk as measured by its use in supplementing a highly purified diet as a source of the vitamin B complex.

The significance of these studies lies in the relation of fresh plant tissue as contrasted with field dried material to subtle changes in the milk secreted.

F.E.S.

Behavior of Caseinate Sols in a Study of a Hysteresis-like Phenomenon in the Rennet Coagulation of Heated Milk. M. E. Powell and L. S. Palmer, Div. of Agr. Biochem., Univ. of Minnesota, St. Paul, Minnesota. J. Dairy Sci. *18*, 6, p. 401, June, 1935.

When artificial "milks" of calcium caseinate-colloidal calcium phosphate are heat-treated at 60° C. and 85° C. and coagulated at 40° C. with rennet at various intervals after heating a progressive loss of coagulability results as rennet addition is delayed. The presence of both the calcium caseinate fraction and the colloidal calcium phosphate fraction during heat-treatment is essential for hysteresis; heating either fraction alone before addition of the other fails to alter the coagulability. Heat-treating the colloidal calcium phosphate fraction causes a marked peptization of colloidal material as well as a decrease in pH, both effects being largely masked by the presence of the caseinate during heating. Heat-treating calcium caseinate "milks" in which oxalic or arsenic acids were substituted for the phosphoric acid fails to produce the hysteresis. A much greater increase in cataphoretic velocity results when calcium caseinate-phosphate "milks" are heat-treated than when a calcium caseinate sol is similarly treated.

M.E.P.

Influence of Season and Advancing Lactation on Butterfat Content of Jersey Milk. R. B. Becker and P. T. Dix Arnold, Florida Agr. Exp. Sta., Gainesville, Florida. J. Dairy Sci. *18*, 6, p. 389, June, 1935.

Analyses of variance of average monthly butterfat tests in 293 lactations by Jersey cows in Florida ranged between 4.76 per cent in August and 5.46 per cent in December. Fat tests dropped from 4.96 the first month after calving in the Florida Jerseys, to 4.59 per cent in the second month, increasing gradually thereafter to 5.55 per cent in the twelfth month.

A.C.D.

Period of Lactation and the Direct Titratable Chloride Value of Milk. Paul F. Sharp and Earle B. Struble, Dept. of Dairy Industry, Cornell Univ., Ithaca, N. Y. J. Dairy Sci. *18*, 8, p. 527, Aug., 1935.

The direct titratable chloride value fell rapidly during the first few days of lactation, reached a minimum, increased slightly during the first

60 per cent of the lactation period and then increased rapidly, particularly during the last 10 per cent of the period. The chloride value bears an inverse relation to the amount of milk produced. At the same level of production Holstein milk was found to be higher in chloride than Guernsey or Jersey milk.

The first and last milk drawn from quarters infected with mastitis was found to be high in chloride and pH and low in titratable acidity, while the middle portion often approached or fell within the range of normal milk. The fraction of the total milking of the quarter of the udder and the different quarters themselves had little effect on the chloride values of the normal milk from healthy cows. P.F.S.

Investigations on the Milk of a Typical Herd of Shorthorn Cows. III. Nitrogen Distribution, Chloride, Lactose, Copper and Iron Content Over a Period of Two Years. WILLIAM LEWIS DAVIES, National Inst. for Res. in Dairying, Univ. of Reading, England. J. Dairy Res. *6*, 3, p. 363, Sept., 1935.

Weekly samples of typical milk from a small herd of Shorthorn cows were taken over a period of two years. In all, 96 samples were analyzed for chlorine content and nitrogen distribution, 75 samples for lactose content, and 24 samples for copper and iron. The following average percentage composition is arrived at:

Fats	3.24 per cent
Solids not fat	8.90 per cent
Lactose	4.81 per cent
Chloride	0.086 per cent
Total protein	3.00 per cent
Casein	2.45 per cent
Albumin	0.428 per cent
Globulin	0.147 per cent
Copper	0.000041 per cent
Iron	0.000196 per cent

The magnitude of the variations in the amount of the total nitrogen accounted for by the albumin and globulin singly is higher than for any of the other nitrogen fractions, although the sums of both naturally show little variation. The albumin was found to vary 14 per cent on either side of the mean, and the globulin 23 per cent. Contrary to general opinion, the mean figure for globulin nitrogen is definitely less than for non-protein nitrogen. The general nitrogen distribution on a percentage basis in milk given by Davies is modified to: Casein, 77; Albumin, 13; Globulin, 4; Non-protein, 6.

Generally the change in the percentages of the constituents studied occurred in the same direction simultaneously. This additive effect caused

the solids-not-fat content during the drought of 1933 to drop below 8.5 per cent on five occasions. The two main constituents concerned, of course, were the lactose and the casein. The variation in the lactose content was less than for the protein.

The chloride content generally varied inversely with the solids-not-fat content. No seasonal variation was observed in the copper and iron contents of samples of milk taken once monthly. H.A.B.

The Yield and Composition of the Milk of the Ewe. W. GODDEN AND C. A. PUDDY, The Powell Res. Inst., Aberdeen, Scotland. J. Dairy Res. *6*, 3, p. 307, Sept., 1935.

Figures are given for the yield, specific gravity and detailed composition including ash constituents for the milk produced by eight Cheviot ewes. A.C.D.

The Influence of High Environmental Temperature on the Secretion and Composition of Milk, a Preliminary Note. S. BARTLETT, The National Inst. for Res. in Dairying, Univ. of Reading, England. J. Dairy Res. *6*, 3, p. 283, Sept., 1935.

Two pairs of cows were housed alternately at 40° F. and 80° F. and the effect on the composition of the milk noted. The higher temperature reduced the milk yield 0.16 pound per day and the fat percentage 0.04, neither change being considered significant.

A significant change was observed only in the case of the solids-not-fat, which on the average decreased 0.153 per cent due to the higher temperature. Regarding the other constituents of the milk and blood, the changes, if any occurred, were not measurable in this small scale experiment. It is concluded that high temperature is not the only factor responsible for milk of low chemical quality produced during summer months. H.A.B.

Studies of the Values of Different Grades of Milk in Infant Feeding. J. A. NEWLANDER AND C. H. JONES, Animal and Dairy Husbandry Dept., Vt. Agr. Exp. Sta., Burlington. Vt. Agr. Exp. Sta. Bul. 389, May, 1935.

The relative values of normal cow's milk, evaporated milk, powdered whole milk (two brands) and remade milk for infant feeding were studied in trials with baby pigs.

It is generally held by nutritionists that the results attained with young pigs may be applied to the feeding of the human infant because of the physiological similarity of their digestive systems. It is recognized of course that a pig at birth is more fully developed than is the babe and that it matures more rapidly; however, it may be assumed with some degree of assurance that

each week of early porcine life approximately corresponds to two or three months of an infant life. The feedings began at two days after birth and continued until the pigs were from two to five weeks of age, which periods would resemble approximately the initial year in human life.

Comparisons, based on the vigor of the animals while on trial, on the total gains, on the amount and economy of dry matter gain and on the body composition, show that the normal milk which was used as the base of all the trials proved best, the evaporated milk and powdered whole milk No. 2 were second best, while remade and powdered whole milk No. 1 were somewhat less serviceable.

Compared with pigs on sow's milk, favorable dry matter gains were made on normal, evaporated, and powdered milk No. 2; less favorable gains on powder No. 1 and least favorable gains on remade milk. In economy of dry matter gains the normal milk ranked first, followed closely by the evaporated and powdered milk No. 2 and less closely by the powdered No. 1 and remade milks.

Marked changes in body composition occurred coincident with increased age. Baby pigs at birth contain about 80 per cent water, protein comprises the greater part of their dry matter content averaging over 60 per cent, while their ash and fat contents each average 17 per cent, the fat to protein ratio being about 1:3.6. As age advances the dry matter and fat percentages decidedly increase. In a well-developed pig at weaning age the dry matter percentage will be approximately 50 per cent greater and of fat 150 per cent greater than they are at birth, and the relative percentages of fat and protein will be nearly equal.

Stomach capacities of the check and experimental pigs were determined at salughtering time. The data obtained indicate that, with the possible exception of some of the initial feedings, there was ample room for the quantities of milk given at a feeding. J.A.N.

Milk-distribution Costs in West Virginia. I. A Study of the Costs Incurred by 22 Plants During 1933. R. O. Stelzer and L. M. Thurston, Morgantown, W. Va. W. Va. Agr. Exp. Sta. Bul. 266, 1935.

A study of the 1933 records from 22 milk-distributing plants in West Virginia was made. The cost of milk distribution for these plants was found to be $2.05 per 100 pounds of milk purchased. These plants paid an average of $1.64 per cwt. for the milk used for fluid sales purposes, which included fluid milk, coffee- and whipping-cream, buttermilk, skimmilk, chocolate milk, cottage cheese, and surplus milk in the form of cream. The total cost of milk and cost of distributing average $3.69 per cwt. or 7.94¢ per quart. The cost of milk to the various plants ranged from $1.26 to $2.25 per cwt. and the cost of distribution from $1.41 to $2.91, whereas the total of these two items ranged from $3.05 to $5.02 per cwt. The cost of milk to plant did not

represent the price paid the producer but was the cost of the milk delivered at the plant.

Labor was the largest item of distributing cost, amounting to 84.1¢ per cwt., equal to 41 per cent of the distributing cost. Depreciation costs averaged 22¢ per cwt., the range being from 8.4¢ to 33.4¢. Depreciation varied considerably for the individual plants because of the rate of depreciation charged, kind and amount of investment per plant, amount of property rented, and volume of milk handled. The plants that rented the land and buildings used in distributing milk had the lowest depreciation costs.

Supplies, repairs, taxes, insurance, and such other items incurred in the care and operation of the buildings and equipment cost 57.5¢ per cwt. The remaining distribution costs for the 22 plants were as follows: loss of milk, 4.7¢; bad debts, 7.0¢; interest costs, 17.7¢; advertising, 2.2¢; and all other costs, 9.8¢ per cwt. of milk purchased.

An average of 1,663, 034 pounds of milk were purchased in 1933 by each plant, the largest plant purchasing more than 5,000,000 pounds and the smallest, 203,228. Of the total quantity of milk purchased, approximately 53 per cent was sold as fluid milk, 19 per cent as fluid cream, and 23 per cent as other products, the remaining 5 per cent being lost or not accounted for in the disposal figures. The data indicate that approximately 70 per cent of the sales of milk and cream were at wholesale prices and the other 30 per cent at retail prices.

The gross value of the sales was $3.57 per cwt. of milk purchased for 17 of the 22 plants. This represents a gross sales value of 7.67¢ per quart of milk. These same 17 plants paid $1.54 per cwt. of milk. The difference between the gross sales value and the cost of milk, amounting to $1.93 ($3.57–$1.64) was retained by the plants and represents their average spread. The total operating cost of these 17 plants was $1.91 (excluding interest not paid), which indicates that the average profit was 1.2¢ per cwt. of milk purchased. A profit of 1.2¢ per cwt. was equal to a return of 0.44 per cent on the average investment for the year, or is equal to 1¢ profit for each 39 quarts of milk equivalent sold. L.M.T.

A Study of the Consumption of Dairy Products in Minneapolis in 1934. Warren C. Waite and Rex W. Cox, Div. of Agric. Economics, Minn. Agr. Exp. Sta., St. Paul, Minn. Minn. Agr. Exp. Sta. Bul. 311, Oct., 1934.

Information for this study was secured by enumerators from 2187 families, which included 8783 persons, living in 228 selected areas in the city. Rates of consumption are given for milk, cream, butter, cheese, evaporated and condensed milk, and ice cream. The authors present an analysis of the factors influencing rates of per capita consumption in the various families and consider certain phases of competition between products.

The consumption of dairy products as a whole tends to increase with income. In the lowest income group, the monthly consumption of butterfat in all products average 3.11 pounds per capita and rose steadily to 5.14 pounds in the highest income group. The number of children in the family is the dominant factor in determining the rate of milk consumption, with income less important than in the case of other dairy products. The rate of butter consumption is largely determined by the per capita income of the family. Cream is purchased almost exclusively by families in the higher-income groups. Condensed and evaporated milk are used largely as a substitute for fluid milk and cream and per capita consumption is largest in the low-income groups. Cheese is consumed at more nearly uniform rates in all groups than the other manufactured dairy products, although there is a higher rate of consumption in the high-income groups. The consumption of ice cream varies largely with income. Increases in income may be expected to increase materially the fluid milk and butter consumption in the low-income group; increase butter consumption slightly, cream consumption a great deal, and fluid milk slightly in the medium-income group, and change consumption hardly at all in the higher-income group. Twenty-two tables of data are reported. S.T.C.

MISCELLANEOUS

Effect of Various Phases in the Manufacture of Casein by the Natural Sour Method on its Physical and Chemical Properties. D. R. Theophilus, H. C. Hansen, R. S. Snyder, R. E. Wood, and R. L. Olmstead, Dept. of Dairy Husb., Ida. Agr. Exp. Sta., Moscow, Idaho. Ida. Agr. Exp. Sta. Bul. 212, May, 1935.

Results obtained from the analyses of 20 lots of casein made by the natural sour curd method under controlled conditions showed that with standard methods a uniform, high quality casein could be produced.

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The variations in the manufacturing process that had the greatest effect on quality were the thoroughness of washing, acidity at time of coagulation, and setting and cooking temperatures. Color, odor, solubility, viscosity, pH, and conductivity determinations appeared to be the best indexes of quality. The results also showed that by varying different steps in the manufacturing process casein could be made to meet any definite specifications. D.R.T.

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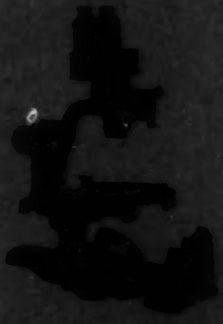

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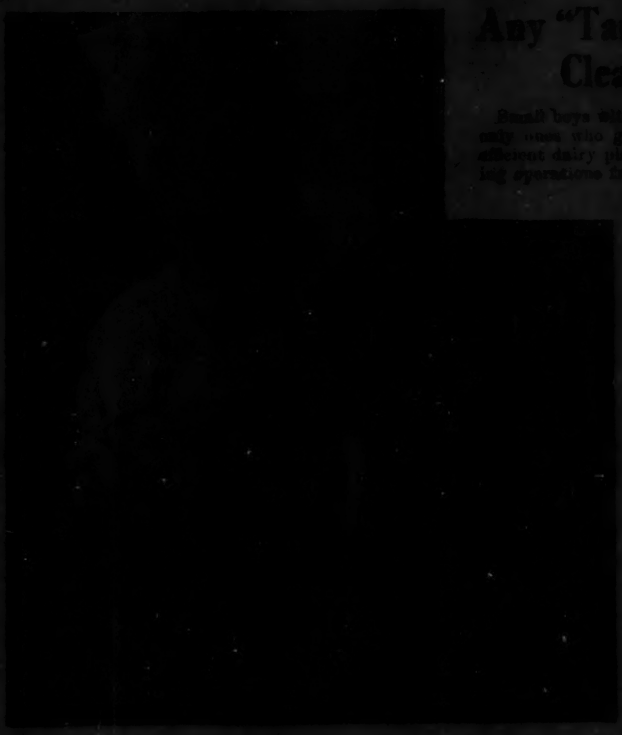

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